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Late Cretaceous Ammonites from the Izumi Mountains, Southwest Japan*

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和泉山脈産の後期白亜紀アンモナイト

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現地の熱心な方々の収集した資料をもとにして，和泉山脈の上部白亜系（和泉層群）産のアンモナイトを研究した結果，18種（第３表）を識別，これらを図示・記載し，類似種との比較を試みた．産地はおもに基底礫岩の上位の砂質泥岩中の８地点（第１図，第２表）で，それらは異なる２層準（第１表の層序表中のＡ２とＢ５）に大別される．他にタービダイト相（層準はＢ３に相当）中の１地点がある．Ａ２とＢ５とでは特徴種に違いが見られる．Ｂ５の特徴種は北海道の K6b2（ヘトナイ統上部階の上部）と同一または極近似で，この層準はマストリヒチアン階に対比される．Ａ２のものには，国際対比でカンパニアン階の種に類似するものが多い反面，マストリヒチアン階におよぶ部類のものも含まれており，この層準が両階境界付近に当たる可能性が示唆される．両階境界問題もからみ，更によい資料を探求しなければならない．なお，フォーナの地域性の問題ならびに生息環境と堆積相についても論述した．

Introduction

For some reasons, only a few ammonites species have been fully described from the Upper Cretaceous Izumi Group. Apart from the work of YABE (1901-2, 1915) on ammonites from the island of Awaji, KOBAYASHI (1931) reported the occurrence of some ammonites from the Izumi Mountains, illustrating two species without description. MATSUMOTO (1936) described one of them, without final determination of the specific name. OBATA and MATSUMOTO (1963) described, in their monograph of the Baculitidae, a species of *Baculites* (*B. regina* OBATA and MATSUMOTO) on numerous specimens from the same area. Anyhow, the hitherto described ammonites from this area are very few.

Meanwhile, several gentlemen in this province attempted enthusiastic hunting of fossils from the Izumi Group, and have obtained quite a number of specimens, which constitute the main material of this study. Moreover, students of Osaka City Univer-

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sity have also obtained in their field work some more specimens, which have been also at our disposal through Professor K. ICHIKAWA.

This paper is to present the results of our study on the Late Cretaceous ammonites from the Izumi Mountains.

Before going further we record here the indications of the collections and the names of the gentlemen, whom we wish to thank sincerely for their kindness of supplying us their valuable collections as the basic material of the present study:

JM : Junichi MIYAMOTO, MK : Motohiro KUWANO

MT : Masanori TANI, SK : Sueo KANEKO

YT : Yukio TAHARA

OMNH : Osaka Museum of Natural History (where the late Mr. Masazumi FUJITA's collection was donated; also including collections of Koji KOGAKI, Takuji NISHIOKA, Manzo CHIJI and Yoshiro MOROZUMI)

OCU : Osaka City University (where the specimens collected by the students, Akihiro ITO, K. SHOJI and Keiji YOSHIMURA are kept)

UMUT : University Museum, University of Tokyo (specimens illustrated by T. KOBAYASHI, 1931 on the basis of Chonosuke KATO's collection)

Baculites specimens are kept at Kyushu University (GK), as recorded by OBATA and MATSUMOTO (1963).

We, furthermore, extend our thanks to Dr. Manzo CHIJI, Director of OMNH, Professor Koichiro ICHIKAWA of OCU and Dr. Itaru HAYAMI of UMUT, who gave us every facility for us to study at respective institutions.

This paper is a contribution to the Working Group on the Coniacian-Maastrichtian stages (Leader Dr. Fr. SCHMID) of the IUGS Subcommission on the Cretaceous Stratigraphy (Chairman Professor Tove BIRKELUND).

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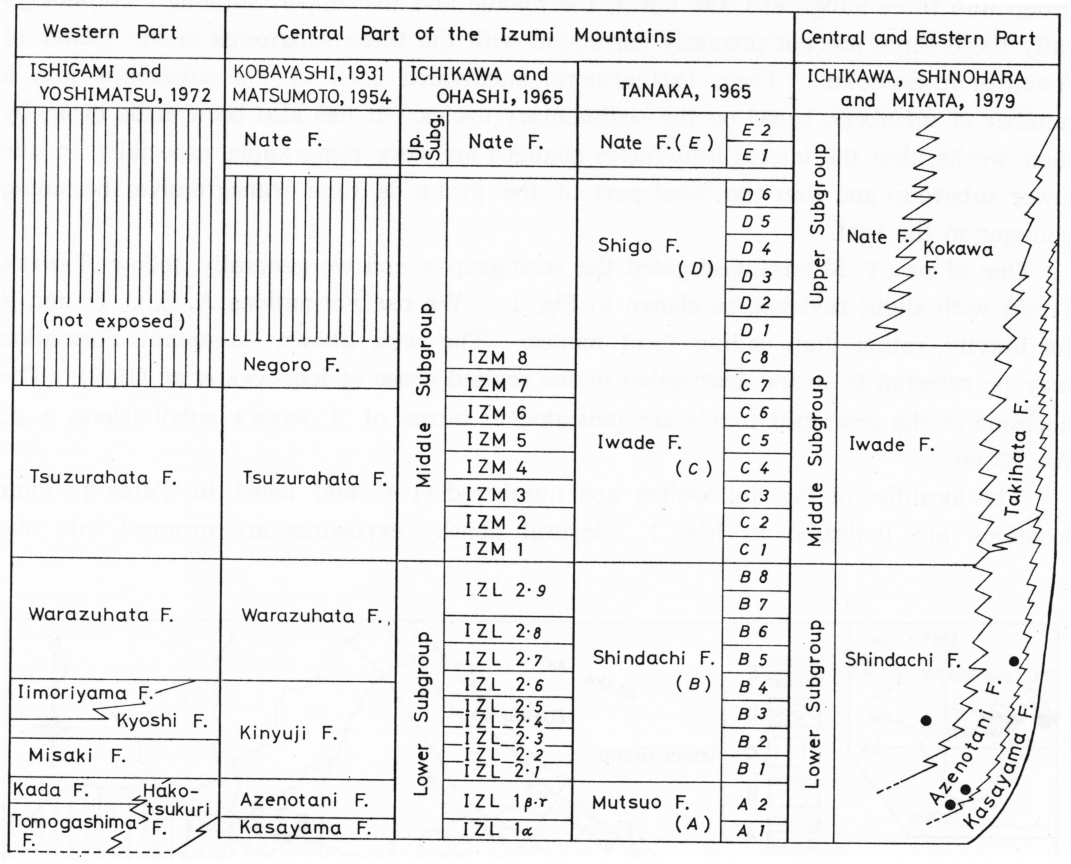
Notes on Stratigraphy

The Izumi Mountains extend equatorially along the prefecture boundary of Osaka and Wakayama (see index map at the upper left corner of Fig. 1). The Upper Cretaceous Izumi Group is distributed for about 300 km from this area westward to Matsuyama (western Shikoku) on the north side of the Median Tectonic Line. It is a thick series of submarine deposits, mainly composed of alternating beds of conglomerate, sandstone and shale of a turbidite facies (TANAKA, 1965). Rather massive siltstone above the basal conglomerate in a narrow northern belt is fairly fossiliferous. The Minato Shale in the island of Awaji (see YABE, 1915) is a well known example of such

Table 1. Stratigraphic division of the Izumi Group in the Izumi Mountains



a fossiliferous part. It can be interpreted that this fossiliferous northern belt may represent a neritic shelf facies in contrast to the main body of the turbidite facies.

For some reasons, the faunules of the representative localities in this northern belt are somewhat dissimilar from one to another. One of the reasons is attributed to the general geologic structure of the Izumi belt, that form an eastward plunging synclinorium, with consequent distribution of younger strata towards the east (e. g., TANAKA, 1965; SUYARI, 1973). This should be supported by biostratigraphic studies, but the fossils have not yet been fully described, except for some special cases.

The stratigraphy of the Izumi Group in the Izumi Mountains has been investigated by a number of authors, among which the scheme of subdivisions by KOBAYASHI (1931), MATSUMOTO (1954), ICHIKAWA and OHASHI (1965), TANAKA (1965), ISHIGAMI and YOSHIMATSU (1972) and ICHIKAWA *et al.* (1979) are shown in Table 1.

TANAKA (1965), ICHIKAWA and OHASHI (1965) and ICHIKAWA *et al.* (1979) divided the group into three subgroups, the lower, the middle and the upper, although chronologically these three are not precisely correlated with the three subgroups in the island of Awaji or in Shikoku. They, furthermore, subdivided each of the subgroups into a number of members, based on the sedimentary cycles. It has also been made clear, by their works, that the lateral litho-facies changes are very remarkable especially in the lower subgroup and that the basal part of the group is time transgressive, becoming younger to the east.

One of us (Y. M.) reinvestigated the stratigraphy and we generally follow TANAKA (1965) with slight revision, as shown in Fig. 1. We use Formations A, B, C, D and E for brevity, rather than calling local names. The well known Azenotani Formation may be referred to in the description in the revised sense of ICHIKAWA *et al.* (1979). The horizons of the described fossils are indicated in terms of TANAKA's subdivisions, e. g., A2, B3 etc.

The localities of the ammonites are numbered (1-9) and listed in Table 2 ; their locations are indicated in Fig. 1. Several nearby exposures are grouped into one

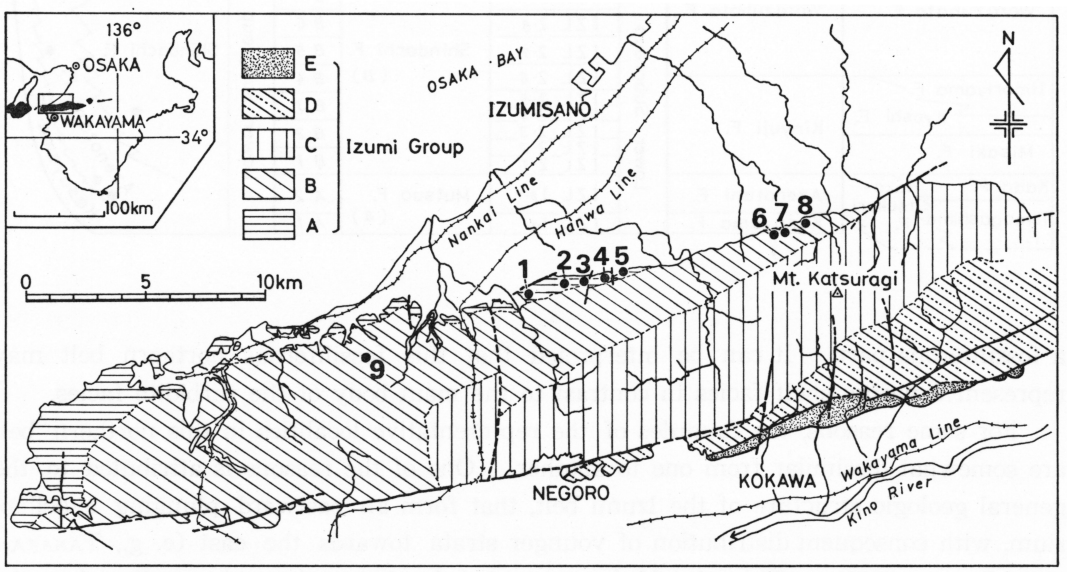


Fig. 1. Geological map of the Izumi Mountains, indicating the ammonite localities 1-9 with small solid circles.

Formations A-E correspond to Mutsuo F.(A), Shindachi F.(B), Iwade F.(C), Shigo F.(D) and Nate F.(E) of TANAKA (1965) respectively in ascending order. Geological map compiled chiefly from TANAKA (1965), ICHIKAWA and OHASHI (1965) and ISHIGAMI and YOSHIMATSU (1972). Inset at the upper left corner index-map indicating the outcropping Izumi Group with solid black and the location of the mapped area with a quadrilateral.

Table 2. Localities of ammonites in the Izumi Mountains

Loc. No.	Location	Horizon
1	about 400m south of Takakurayama, Sennan City, Osaka Prefecture	A2
2	several outcrops around Azenotani, Sennan City, Osaka Pref.	A2
3	an outcrop on the east ridge of the pond of Showaike, Sennan City, Osaka Pref.	A2
4	several cliffs near the bank of the pond of Takinoike, Izumisano City, Osaka Pref.	A2
5	a cliff near the east end of the pond of Shinike, Izumisano City, Osaka Pref.	A2
6	about 1,200m west of Sobura, Kaizuka City, Osaka Pref.	B5
7	roadside cliffs about 800m west of Sobura, Kaizuka City, Osaka Pref.	B5
8	roadside cliffs about 500m northeast of Sobura, Kaizuka City, Osaka Pref.	B5
9	a cliff at Sansaka about 2,500m southeast of Hakotsukuri, Hannan-cho, Sennan-gun, Osaka Pref.	B3

number, since they are of the same horizon.

Stratigraphically these nine localities can be grouped into the following three:

(1) Locs. 1-5, which are all referred to Horizon A2, the Azenotani Formation (s. s.) at or near Azenotani and Takinoike ;

(2) Locs. 6-8, which belong to the Azenotani Formation (diachronous unit as diagrammatically shown in Table 1) at or near Sobura and referred to Horizon B5 ;

(3) Loc. 9, which is an exceptional locality within the conglomerate of the turbidite facies and referred to Horizon B3.

The approximate stratigraphic positions of these grouped localities are indicated in the column of Ichikawa *et al.* (1979) of Table 1.

Palaeontological Descriptions

Family Phylloceratidae Zittel, 1884

Genus *Hypophylloceras* Salfeld, 1924

Subgenus *Neophylloceras* Shimizu, 1934

Type-species.—*Ammonites* (*Scaphites* ?) *ramosus* Meek, 1858.

Remarks.—*Hypophylloceras* was regarded as a subgenus of *Phylloceras* Suess, 1865 by

WIEDMANN (1964), who put *Neophylloceras* SHIMIZU, 1934 as a synonym of it (WIEDMANN, 1962a, b). This was followed by KENNEDY and KLINGER (1977). We do not intend to discuss comprehensively the taxonomy of the family in this paper, but would like to use *Neophylloceras* as a subgenus of *Hypophylloceras*. The criterion to distinguish *Neophylloceras* from *Hypophylloceras* is primarily in the degree of incision of sutures, as is pointed out by SHIMIZU (1934) (in Japanese ; for the translation see WRIGHT and MATSUMOTO, 1954, p. 109). This was regarded as insignificant by WIEDMANN, but we provisionally follow MATSUMOTO (1959a, p. 56) who showed clearly the taxonomic distinction. In the same paper, however, MATSUMOTO pointed out the existence of species which shows somewhat intermediate state in the complexity and multiplication of suture. Therefore, we treat here *Neophylloceras* as a subgenus of *Hypophylloceras*, as BIRKELUND (1965) did. Biostratigraphically *Neophylloceras* ranges from Cenomanian to Maastrichtian.

Hypophylloceras (*Neophylloceras*) sp.
cf. *H.* (*N.*) *hetonaiense* (MATSUMOTO)
Pl. 1, Figs. 1-4

Compare.—

1942. *Neophylloceras hetonaiense* MATSUMOTO, *Proc. Imp. Acad.*, Tokyo 18, p. 675, text-fig. 1 (a3, b3).

1953. *Neophylloceras hetonaiense* : SPATH, *Falkland Islands Dependencies Surv., Sci. Rept.* (3), p. 5, pl. 1, fig. 2.

1959. *Neophylloceras hetonaiense* : MATSUMOTO, *Mem. Fac. Sci., Kyushu Univ., Ser. D, Spec. Vol.* 1, p. 5, pl. 3, fig. 1.

1963. *Neophylloceras hetonaiense* : JONES, *U. S. Geol. Surv. Prof. Paper* (432), p. 23, pl. 6, figs. 9-10 ; pl. 7, figs. 1-5 ; text-fig. 12.

Material.—OMNH. M2123 (coll. by T. NISHIOKA), MT126 and MT148 (M. TANI's Coll.), from Loc. 7 (Sobura) ; SK1(S. KANEKO's Coll.), from Loc. 4 (Takinoike) ; YT57 (Y. TAHARA's Coll.), from Loc. 9 (Sansaka).

Description.—The above specimens are incompletely preserved, but show some characteristic features. Shell is involute, high whorled, ornamented with numerous, dense, fine lirae which run nearly straightly radially on the main part of the flank, showing a gentle convexity at about the middle and then a gently concave curvature on approaching to the umbilical margin. Suture is very finely and deeply incised.

Comparison.—From the observed characters these specimens are probably referable to *H.* (*N.*) *hetonaiense*. While the lectotype and other examples of this species from unit IVb (Lower Sandy Siltstone of the Hakobuchi Group) of the Tomiuchi [=Hetonai] area in Hokkaido are mostly small, the Izumi specimens are 110 to 135 mm in diameter. This is probably due to the difference in growth-stage. One (GK. H3813) of the

Hetonai specimens, though incomplete, is as large as 60 mm in whorl-height but is still septate.

Neophylloceras hetonaiense MATSUMOTO (1942) was originally very briefly described. This species is, however, fairly well maintained in subsequent papers (see above list). Its whorl is much higher than broad (B/H=0.48-0.60), with very gently convex flanks and the maximum breadth at mid-height. In the Izumi specimens the whorls are more or less secondarily compressed.

Occurrence.—Three specimens are from Loc. 7 (Sobura), Horizon B5; another from Loc. 4 (Takinoike), Horizon A2; still another from Loc. 9 (Sansaka), Horizon B3.

Family Pachydiscidae SPATH, 1922

Genus *Canadoceras* SPATH, 1922

Type-species.—*Ammonites newberryanus* MEEK, 1876

Canadoceras tanii sp. nov.

Pl. 2, Fig. 1

Material.—Holotype, MT80 (M. TANI's Coll.), from Loc. 4 (Takinoike), which is fairly well preserved. Incompletely preserved specimens, YT19, 20, 21 and 26 (Y. TAHARA's Coll.), from Loc. 9 (Sansaka) are probably referable to this species. The holotype is now kept in OMNH by the courtesy of Mr. TANI.

Diagnosis.—Shell fairly large. As the last suture is at the diameter of about 180 mm, the entire shell diameter would be more than 230 mm, if the body-chamber was completely preserved.

Whorl higher than broad, with B/H=0.6-0.7 and the maximum breadth in the lower part, narrowly subelliptical or ovoid in section, having gently convex and somewhat convergent flanks and a moderately to narrowly (later) arched venter. Whorls moderately involute, rather rapidly growing in height; accordingly umbilicus fairly narrow, about 25-26 percent of the shell diameter; umbilical wall steep and umbilical shoulder subrounded.

Numerous, gently flexuous ribs of moderate intensity, weakly projected on the venter, separated by a little broader interspaces; about 50 per whorl; as a rule alternately long and short on the main part of the septate shell; some of longer ribs somewhat stronger than others and elevated at the umbilical margin forming umbilical bullae and also accompanied by a shallow constriction. On the last part of the septate shell nearly all the ribs are long, with little or no intercalation of shorter ones; on the body-chamber the ribs are weakened, broadened and less flexuous.

Partly exposed suture show the highly incised pattern of *Canadoceras* type.

Measurements (in mm).—

Specimen	Stage	Diameter	Umbilicus	U/D	Height	Breadth	B/H
MT80	-30° from preserved end	182.0	47.5	0.26	76.0	46.0	0.61
〃	-180° from above	130.0	32.5	0.25	56.0	39.0	0.70
YT26	(sec. compr.)	149.0	34.2	0.23	56.5	32.8	0.58

Comparison.—This species somewhat resembles *Canadoceras hoepeni* COLLIGNON (1955, p. 47, pl. 12, fig. 1 ; 1970, p. 28, pl. 618, fig. 2303), from the Middle Campanian of Madagascar, in the general shell-form and numerous ribs up to the diameter of about 100 mm. In the holotype of *C. hoepeni* the ribs become coarse and fairly distant on the later part, whereas our specimen has denser, more numerous ribs. In *C. hoepeni* the ribs are projected more strongly on the venter and the whorl is not so much compressed (B/H= 0.76-0.80) as in *C. tanii.*

C. multicostatum MATSUMOTO (1954, p. 304, pl. 34, figs. 1-2 ; text-fig. 28), from the Middle and Upper Campanian of South Sakhalin and Hokkaido, has likewise numerous ribs, but *C. tanii* has more compressed whorl, narrower umbilicus, less strongly projected ribs and much shallower constrictions.

Canadoceras jonesi COLLIGNON (1971, p. 42, pl. 657, fig. 2420), from the Lower Maastrichtian of Madagascar, has also numerous ribs which are not much projected on the venter. It has, however, no constriction and more convex flanks; its whorl is less compressed (B/H=0.9) than in *C. tanii.* We doubt whether it is truely referable to *Canadoceras* or not. It may be a species of *Pachydiscus* (*colligatus* group), but we defer the final decision until we look at the actual specimen.

Occurrence.—Azenotani Formation (sandy siltstone) at Loc. 4 (Takinoike), Horizon A2 (holotype). Several specimens which can be called *C.* cf. *tanii* from Loc. 9 (Sansaka), in a conglomerate bed (Horizon B3) of turbidite facies.

Genus *Pachydiscus* ZITTEL, 1884

Subgenus *Pachydiscus* ZITTEL, 1884

Type-species.—*Ammonites neubergicus* HAUER, 1858.

Remarks.—For the most recent account of *Pachydiscus* see MATSUMOTO (Part I) in MATSUMOTO *et al.*, 1979.

Pachydiscus (*Pachydiscus*) *kobayashii* (SHIMIZU)

Pl. 3, Fig. 1 ; Pl. 4, Fig. 1

1931. *Parapachydiscus* aff. *egertoni*: KOBAYASHI, *Jour. Geol. Soc. Tokyo* 38, p. 635, pl. 11.

1935. *Parapachydiscus kobayashii* SHIMIZU, *Jour. Shanghai Sci. Inst., Sect. 2,* 1(11), p. 208.

1936. *Parapachydiscus* aff. *egertoni*: MATSUMOTO, *Jap. Jour. Geol. Geogr.* 13, p. 262, pl. 30, fig. 1 ; pl. 31, fig. 1 ; text-figs. 1a, 2b.

Material.—Holotype, UMUT. MM 7720 〔=I-581〕, from Loc. 2 (north of Azenotani), Azenotani Formation (coll. by C. KATO).

SHIMIZU (1935) proposed the specific name for this specimen figured by KOBAYASHI (1931, pl. 11).

The following specimens in the subsequent collections are referable to this species. On account of incomplete preservation, some of them (with *) may be better called *P.* (*P.*) sp. cf. *P.* (*P.*) ***kobayashii***, but they are useful for us to know some variation as well as specific characters.

SK2 (S. KANEKO's Coll.), from Loc. 1 (south of Takakurayama)
OMNH. M1068 (coll. by M. FUJITA), from Loc. 2 (Azenotani)
*OMNH. M1070 (coll. by M. FUJITA), from Loc. 2 (first branch of Azenotani)
*OMNH. M1066 (coll. by M. FUJITA), from Loc. 3 (Showaike)
*JM21 (J. MIYAMOTO's Coll.), from Loc. 2 (Azenotani)
*OCU. MM775 (coll. by A. ITO), from Loc. 2 (east slope of Azenotani)
*YT25 (Y. TAHARA's Coll.), from Loc. 9 (Sansaka)

Diagnosis.—Shell large, fairly involute and fairly narrowly umbilicate. Whorl higher than broad (B/H=0.71-0.75), subelliptical in section, slightly or somewhat broader in the lower part, with gently convex flanks, moderately arched venter and subrounded umbilical shoulders.

Ribs rather low and blunt, with some variation in strength, nearly rectiradiate to gently concave. Primary ribs start from blunt umbilical bullae, becoming fainter towards the venter; about 7 or 8 in a half whorl of the middle growth-stage, becoming broader and more distant later. Secondary ribs weak, one or two being inserted between the primaries; at first long, starting at some distance from the umbilical margin; later short, confined on the ventrolateral part, becoming finally obsolete.

Suture of the typical *Pachydiscus* pattern. It is very similar to that of *Pachydiscus preegertoni* COLLIGNON (1955, pl. 20, fig. 1, 1b).

Measurements (in mm).—

Specimen	Diameter	Umbilicus	U/D	Height	Breadth	B/H
Holotye	202.0	48.0	0.24	97.0	69.0	0.71
〃 (-90°)	162.0	41.0	0.25	75.0	56.0	0.75
OMNH. M1068	225.0	ca. 50	ca. 0.22	110.0	ca. 80.0	ca. 0.73
OMNH. M1070	—	—	—	110.0	82.5	0.75
OCU. MM775				65.0	49.0	0.75
SK2 (sec. compr.)	275.0	64.0	0.23	124.0	81.0	0.65

Remarks.—The holotype is wholly septate. Still larger specimen (D=275 mm) is septate at its end. Although the well preserved specimen with the complete body-chamber is not available, the entire shell diameter of this species must be very large.

In the late part of the septate stage, the secondary ribs become faint and finally disappear ; whereas distant primary ribs remain. This stage comes somewhat earlier and is manifested unusually in OMNH. M1068, on which coarse major ribs are characteristic.

Comparison.—This species closely resembles *Pachydiscus preegertoni* COLLIGNON (1955, p. 61, pl. 20, fig. 1a, 1b), from the Middle Campanian of Madagascar, but is distinguished by its more compressed whorl (B/H being 0.71-0.75 as compared with 0.78-0.90 of that species in the shells of corresponding size), larger adult shell, and earlier disappearance of secondary ribs.

Pachydiscus egertoni (FORBES) (1846, p. 108, pl. 9, fig. 1), whose lectotype was designated by MATSUMOTO (1959b, p. 42, text-fig. 17), has thicker and more inflated whorls (B/H =0.84 in the lectotype) and is characterized by more distinct differentiation of coarse primary ribs starting from the umbilical tubercles and numerous secondary ribs on the ventral part, with weakening of the ribs at about the middle of the flank.

Occurrence.—Characteristic of the Azenotani Formation (siltstone) at Loc. 2 (Azenotani) ; also that at Loc. 1 (south of Takakurayama) and Loc. 3 (Showaike), Horizon A2. Another isolated Loc. 9 (Sansaka) in a conglomerate bed of turbidite facies, Horizon B3.

Pachydiscus (*Pachydiscus*) sp.
aff. *P.* (*P.*) *flexuosus* MATSUMOTO
Pl. 5, Fig. 1 ; Pl. 6, Fig. 1 ; Pl. 7, Fig. 1

Compare.—

1979. *Pachydiscus* (*Pachydiscus*) *flexuosus* MATSUMOTO, *Mem. Fac. Sci., Kyushu Univ., Ser D,* 24 (2), p. 53, pl. 9, figs. 1-3 ; pl. 10, fig. 4 ; pl. 12, fig. 1 ; text-fig. 4.

1979. *Pachydiscus* (*Pachydiscus*) *flexuosus*: MATSUMOTO and YOSHIDA, *Ibid., Ser. D,* 24(2), p. 67, pl. 12, figs. 3-4.

Material.—MT204 and MT70 (M. TANI's Coll.) from Loc. 7 (Sobura). Fossils are coated with black material.

Description.—As MT204 has a trace of the umbilical seam of a missing outer whorl, the shell must have been very large. MT70 about 200 mm in diameter, is still septate.

Whorl is higher than broad, with B/H=0.72-0.75 in MT204 and 0.67 in MT70 (which is secondarily compressed), compressed ovoid in section, with the maximum breadth in the lower part. Umbilicus is fairly narrow and surrounded by a steep umbilical wall, as seen in MT70.

Ribs are numerous, narrow, rather weak and gently flexuous; about 11 or 12 longer ribs in a half whorl, with some infrequently intercalated shorter ones. At the umbilical shoulder the ribs are somewhat thickened, without forming distinct tubercles. The ribs are much weakened at late stage and the outer whorl is almost smooth.

The partly exposed suture is deeply and finely incised, leaving very narrow stems of the elements as in *P.* (*P.*) *flexuosus.*

Measurements (in mm).—

Specimen	Diameter	Umbilicus	U/D	Height	Breadth	B/H
MT204	178.0	ca. 35	ca. 0.20	90.0	65.0	0.72
MT70 (sec. compr.)	195.0	42.4	0.22	91.0	ca. 54.0	ca. 0.59

Comparison.—With respect to the fairly involute, high whorls, with a compressed suboval section and the gently flexuous ribs with feeble umbilical bullae, the Izumi specimens resemble the holotype and other examples of *Pachydiscus* (*Pachydiscus*) *flexuosus* MATSUMOTO, from the Maastrichtian equivalent (K6b2) of Hokkaido. In that species the longer primary ribs are not so numerous as in the Izumi specimens and the shorter secondary ribs are more distinctly differentiated at the middle growth-stage. On the outer whorl of the holotype and some other examples of *P.* (*P.*) *flexuosus,* a peculiar, shallow constriction-like depression is developed. This character is not confirmed on the preserved outer whorl of the Izumi specimens.

MT204 is fairly similar to the holotype of *P.* (*P.*) *hidakaensis* MATSUMOTO and KANIE (*in* MATSUMOTO *et al.,* 1979, p. 64, pl. 13, fig. 1 ; text-fig. 8), from the probable Maastrichtian of the Urakawa district, Hokkaido, but the ribs in that Urakawa specimen have no or little flexuosity, showing a concave curvature.

Although the Izumi specimens might be within the variation of *P.* (*P.*) *flexuosus,* they are provisionally called *P.* (*P.*) sp. aff. *P.* (*P.*) *flexuosus* MATSUMOTO, since there are such dissimilar points as mentioned above.

Occurrence.—Fine sandy siltstone at Loc. 7(Sobura), Horizon B5.

Subgenus *Neodesmoceras* MATSUMOTO, 1947

Type-species.—*P.* (*Neodesmoceras*) *japonicus* MATSUMOTO, 1947

Pachydiscus (*Neodesmoceras*) sp.
cf. *P.* (*N.*) *gracilis* MATSUMOTO
Pl. 8, Figs. 1-2; Pl. 9, Fig. 1 ; Pl. 10, Figs. 1-2

Compare.—

1979. *Pachydiscus* (*Neodesmoceras*) *gracilis* MATSUMOTO, *Mem. Fac. Sci., Kyushu Univ., Ser. D,* 24(2), p. 60, pl. 10, figs. 1-3 ; pl. 11, fig. 1 ; pl. 12, fig. 2 ; text-fig. 6.

Material.—MK852 (M. KUWANO's Coll.) from Loc. 6 ; MT280 and MT102 (M. TANI's Coll.), from Loc. 7 ; JM17 and JM19 (J. MIYAMOTO's Coll.), from Loc. 8 ; OMNH. M2146 and M2147 (coll. by Y. MOROZUMI), from Loc. 8 ; OCU. MM774 (coll. by K. YOSHIMURA), from Loc. 7, all in the vicinity of Sobura. Fossils are coated with black substance.

Description.—Shell is fairly large. The largest example is MT102, whose diameter is about 280 mm at the preserved end. MK852, about 115 mm in diameter, is wholly septate and has a trace of the umbilical seam of still outer two thirds whorl.

Whorl is higher than broad, suboval to compressed ovoid in section, broader in the lower part ; flanks gently convex and convergent to the more or less narrowly arched venter. Umbilicus fairly narrow, surround by low but nearly vertical wall and subangular to subrounded shoulder.

Surface is nearly smooth, with some lirae and occasional remnants of faint ribs, which show a gently sigmoidal curvature ; no umbilical tubercle.

For some reasons sutures are not well exposed. The exposed part shows fine and deep incisions of *Pachydiscus* pattern.

Measurements (in mm).—

Specimen	Diameter	Umbilicus	U/D	Height	Breadth	B/H
MK852 (sec. compr.)	112.0	21.6	0.19	57.5	37.2	0.65
MT102 (sec. compr.)	275.0	58.0	0.21	130.0	68.0	0.52
MT280	84.0	20.0	0.24	38.0	26.0	0.68
GK. H5885 (holotype)	147.0	32.0	0.22	68.0	49.0	0.72

Comparison.—The described specimens from Sobura agree well in essential points with the holotype and other examples of *Pachydiscus* (*Neodesmoceras*) *gracilis* MATSUMOTO, from Hokkaido.

JM17 has a relatively thicker body-chamber, whose section is subtrigonal, as compared with its inner whorl and other specimens. The same feature is seen in a large specimen, GK. H5896, from Hokkaido.

Thus the Izumi specimens are probably identified with *P.* (*N.*) *gracilis*. As they are, however, more or less incompletely preserved, we call them *P.* (*N.*) sp. cf. *P.* (*N.*) *gracilis* MATSUMOTO.

Occurrence.—Fine sandy siltstone at Locs. 6, 7 and 8 (Sobura), Horizon B5.

Family Gaudryceratidae SPATH, 1927

Genus *Gaudryceras* de GROSSOUVRE, 1894

Type-species.—*Ammonites mitis* HAUER, 1866

Remarks.—Some remarks have recently been given on this genus by MATSUMOTO and YOSHIDA (1979) and KENNEDY and KLINGER (1979).

***Gaudryceras izumiense* sp. nov.**

Pl. 11, Fig. 1 ; Pl. 12, Fig. 1 ; Pl. 13, Fig. 1

1931. *Gaudryceras tenuiliratum*: KOBAYASHI (*non* YABE), *Jour. Geol. Soc. Tokyo* 38, pl. 10.

Material.—Holotype : OMNH. M1125 (coll. by M. CHIJI), from Loc. 7 (Sobura) (Pl. 11, Fig. 1). Two other illustrated paratypes : MT 54 and MT82 (both M. TANI's Coll.), from Loc. 7. Also JM 180 (J. MIYAMOTO's Coll.), from Loc. 5 (Shinike). Fossils are coated with black substance.

Other fragmentary specimens (which should be called *G.* sp. cf. *G. izumiense*) : OMNH. M1069, from Loc. 7 (west of Sobura) and OMNH. M1071, from Loc. 7 (Suberidani), both coll. by M. FUJITA ; OCU. MM 773, from Loc. 7 (between Nakanotani and Ohtani, near Sobura) (coll. by K. SHOJI) and UMUT. MM 7711 〔=I-570〕, from Loc. 7 (Nakanotani near Sobura) (coll. by C. KATO and illustrated by KOBAYASHI, 1931, pl. 10). Also JM123 (J. MIYAMOTO's Coll.) and YT195B (Y. TAHARA's Coll.), from Loc. 9 (Sansaka).

Diagnosis.—Shell fairly large, about 230 mm in diameter at the adult stage, consisting of polygyral ($9+\alpha$) whorls. Umbilicus moderately wide (33-35% of D) even at the adult stage, surrounded by nearly vertical wall and then abruptly rounded shoulder. The last whorl is higher than broad, increasing rather rapidly in height, broader in the lower part, with the maximum breadth somewhat above the umbilical shoulder ; gently convex flanks converging to a rather narrowly arched venter. Inner whorls more rounded as in many species of *Gaudryceras*.

Surface of shell ornamented with numerous flexiradiate lirae and periodic narrow major ribs. The major ribs are 6-10 in the last whorl. The lirae are comparatively coarser, more elevated and more distant at and near the umbilical shoulder than on the outer part. They are fine and dense on the ventral part. The lirae on the venter are 4-5 times as numerous as those on the umbilical margin by the intercalation which takes place more than twice at several places on the flank. The lirae and the ribs run forward on the umbilical wall and the shoulder, passing gradually to a convex curve on the lower part of the flank, and slightly recurved at about the midde of the flank to show a gentle flexousity, but the projection on the ventrolateral part is so slight that the lirae and the major ribs look nearly radial on the outer part of the flank and cross the venter almost vertically.

Probably because the outer shell layer is not preserved, the inner whorls of the examined specimens look smoothish. Presumably the lirae may be finer than on the outer whorl and the constrictions are shallow.

Partly exposed suture is of *Gaudryceras* pattern.

Measurements.—

Specimen	Diameter	Umbilicus	U/D	Height	Breadth	B/H
OMNH. M1125	230.0	80.0	0.35	92.0	64.4	0.70
〃 (-90°)	185.0	64.0	0.35	73.0	56.0	0.77
〃 (-180°)	—	—	—	58.0	46.0	0.79
MT82 (ant. end)	233.0	79.0	0.34	92.0	55.0	0.60

〃 (-30°)	218.0	72.5	0.33	90.0	61.5	0.68
〃 (-180°)	—	—	—	62.0	46.5	0.75
MT54	198.0	62.6	0.32	85.3	58.4	0.68
〃 (-180°)	—	—	—	52.0	42.0	0.81
OCU. MM773	198.0	67(?)	0.34	76.0	60.6	0.80
JM180	—	—	—	78.0	53.0	0.68

Remarks.—In all the examined specimens the body-chamber is preserved. In MT82 the last portion in front of the last major rib is somewhat reduced in size and ornamented with two subsidiary ribs, which are narrower and shorter than the normal major rib and covered with dense lirae. This part probably represents the apertural end of the adult shell. In this specimen the body-chamber is slightly longer than a half whorl, occupying about 210°. Unfortunately the septate shell of this interesting specimen is badly squashed. It should be noted that the holotype and another illustrated paratype are nearly of the same size as this adult specimen.

Comparison.—This species is closely allied to *Gaudryceras tenuiliratum* YABE, 1903, the lectotype of which is *Lytoceras sacya* in YOKOYAMA, 1890, p. 178, pl. 18, fig. 13 〔*non* FORBES, 1846〕, from Efue of the Urakawa district, as designated by MATSUMOTO *in* MATSUMOTO *et al.* (1963, p. 29) (see also JONES, 1963, p. 28). It is, however, distinguished by its unmistakably larger size (with diameter of the adult shell about 230 mm in *G. izumiense* as compared with 100 mm or so in *G. tenuiliratum*) and its greater multiplication of lirae towards the venter (the ventral lirae being 4-5 times as numerous as the umbilical ones in *G. izumiense* as compared with 1.5-2.5 〔less than 3〕 times in *G. tenuiliratum*) on the adult living chamber. *G. izumiense* is more polygyral and has a wider umbilicus and a higher body-whorl with more narrowly arched venter than *G. tenuiliratum,* although the distinction in shell-form between the two species may be slight at immature stages. The lirae and the major ribs are more distinctly flexuous, with a ventral projection in *G. tenuiliratum.*

G. tenuiliratum of JONES (1963, p. 26, pl. 9, figs. 1-3; pl. 10, figs. 1-3), from the Zone of *Pachydiscus kamishakensis* of southern Alaska, is not identified with the present species nor with true *G. tenuiliratum* in that it has numerous secondary ribs instead of the lirae on the last whorl. It is noted, however, that even in the latter two species some of the lirae are so coarse around the umbilicus of the outer whorl that they have corresponding faint subcostae on the internal mould.

G. izumiense is distinguished from *G. lauteli* COLLIGNON (1956, p. 57, pl. 7, figs. 1, 1a, 1b) by its wider umbilicus at the adult stage and less flexuosity of the ribs with little or no ventral projection. The latter species ranges in Madagascar from the Santonian-Campanian passage bed to the basal Middle Campanian. Incidentally *G. lauteli* looks similar to *G. tenuiliratum* but its holotype and some other examples are larger than the latter.

Occurrence.—A number or specimens, including the holotype, from Loc. 7 (Sobura), Horizon B5. A single specimen from Loc. 5 (Shinike), Horizon A2 and two other fragmentary specimens from Loc. 9 (Sansaka), from a conglomerate bed (Horizon B3) of the turbidite facies.

Family Tetragonitidae HYATT, 1900

Genus *Pseudophyllites* KOSSMAT, 1895

Type-species.—*Ammonites indra* FORBES, 1846

Pseudophyllites (?) sp.
Pl. 1, Fig. 5

Material.—JM 20 (J. MIYAMOTO's Coll.) from Loc. 8 (Sobura) and SK6 (external mould) (S. KANEKO's Coll.) from Loc. 2 (Azenotani).

Description.—The specimens are small, probably immature, with the following dimensions:

Specimen	Diameter	Umbilicus	U/D	Height	Breadth	B/H
JM20	28.0	4.5	0.16	13.5	12.5(?)	0.93
SK6	11.0	1.7	0.15	ca. 5.0	—	—

The whorl is rounded, slightly higher than broad at this small stage, showing rapid growth of height. Umbilicus is faily narrow.

Very fine lirae are discernible on some part of the shell surface, which are similar to those of *P. indra*.

Suture is partly exposed, showing tripartite saddle between E and L.

Comparison—The two specimens are probably referable to *Pseudophyllites* and resemble immature examples of *P. indra* (FORBES), from the Upper Campanian-Maastrichtian of India, Madagascar, South Africa, Hokkaido, Alaska, British Columbia and Baja California. They are too poorly preserved for the precise identification.

Occurrence.—Rarely found at Loc. 8 (Sobura), Horizon B5 and Loc. 2 (Azenotani), Horizon A2.

Family Nostoceratidae HYATT, 1894

Genus *Nostoceras* HYATT, 1894

Type-species.—*Nostoceras stantoni* HYATT, 1894

Remarks.—We follow STEPHENSON (1941, p. 407) and HOWARTH (1965, p. 374) for the redefinition of this genus. For further remarks see LEWY (1967, p. 165) and MATSUMOTO (1977, p. 322).

Nostoceras sp. A
aff. *N. kernense* (ANDERSON)
Pl. 14, Fig. 2

Compare.—

1958. *Didymoceras kernense* ANDERSON, *Geol. Soc. Amer., Mem.* 71, p. 196, pl. 65, figs. 1-2.

Material.—OMNH. M1150a, b (internal and external moulds) (coll. by K. KOGAKI) from Loc. 7 (Akiyama, west of Sobura).

Description.—A strongly bent U-shaped specimen of moderate size, about 30 mm in diameter of whorl-section, 70-75 mm and about 65 mm in length and breadth of U, with 2-6 mm space between the two limbs.

The shell is ornamented with moderately strong ribs (see Pl. 14, Fig. 2) at moderate distance, five or six within the interval equal to the whorl-breadth. They are nearly vertical to the axis of growth but somewhat rursiradiare on the curved part of U. On the last part (i. e. for some interval near the apertural end) the ribs are mostly simple and devoid of tubercle. Otherwise, two rows of tubercles occur at each second rib. On the first limb and the curved part of U, some of the ribs are looped at the tubercles, some others branched without tubercle at the dorsolateral part and still others are simple.

No septum in the preserved part of the specimen.

Comparison.—This specimen probably represents the body-chamber of a *Nostoceras* species. In fact it resembles *Nostoceras kernense* (ANDERSON) (1958, p, 196, pl. 65, figs. 1-2), which is represented by the body-chamber only from a bore-hole at Buena Vista Hills, California and supplemented by another probable example from Angola (HOWARTH, 1965, p. 381, pl. 8, fig. 6), but in that species the branching of the ribs and the looping of them at the tubercles occur more frequently than in ours.

The present specimen somewhat resembles the body-chamber of *Nostoceras hyatti* STEPHENSON (1941, p. 410, pl. 81, figs. 9-12), from the Nacatoch Sand of the Navarro Group (Texas), Uppermost Campanian or Lowest Maastrichtian of Angola (HOWARTH, 1965, p. 378, pl. 9, figs. 1-2 ; pl. 10, fig. 1 ; text-fig. 1b) and New Jersey (COBBAN, 1974, p. 10, pl. 5, figs. 1-21 ; pl. 6, figs. 1-12 ; pl. 7, figs. 1-10 ; pl. 8, figs. 1-30 ; text-fig. 8). It differs from that species in that the tubercles occur at every second (instead of every) rib on its body-chamber and that its ribs are sometimes bifurcated at the dorsolateral part.

To sum up, this probably represents a new species of *Nostoceras* which is allied to but distinct from *N. kernense* and *N. hyatti.* Until more and better material is obtained, we defer to propose a new name.

Occurrence.—Silty fine sandstone at Loc. 7 (Akiyama, west of Sobura), Horizon B5.

Nostoceras sp. B
aff. *N. hetonaiense* MATSUMOTO
Pl. 14, Fig. 1

Compare.—

1977. *Nostoceras hetonaiense* MATSUMOTO, *Mem. Fac. Sci., Kyushu Univ., Ser. D,* 23(3), p. 322, pl. 54, fig. 2 ; pl. 55, fig. 1.

Material.—MT 137 (M. TANI's Coll.), from Loc. 4 (Takinoike).

Description.—This is again a U-shaped last hook which continues from the last portion of helical coiling. The dimensions of the whorl are H=22, B=20 mm at the preserved posterior end and H=30, B=22.5 mm near the apertural end. Length of the last arm 67 mm and breadth of U-form 65 mm, with the space of 7-12 mm between the two arms.

The shell is ornamented with numerous, closely spaced ribs, which consist of simple and bifurcated ones. The latter are mostly provided with tubercles at the bifurcating point, forming loops. On the earlier limb of U-shaped body-chamber one or two simple ribs are alternated with the bifurcated ones ; on the later limb simple ribs without tubercles are more predominant.

The last septum is impressed on the posterior end of the body-chamber specimen, but the details of the sutural pattern is not exposed.

Comparison.—This specimen closely resembles in the mode of ornamentation the body-chamber of *Nostoceras hetonaiense* MATSUMOTO (1977, p. 322, pl. 54, fig. 2 ; pl. 55, fig. 1), from the Lower Sandy Siltstone of the Hakobuchi Group in Hokkaido. They are nearly of the same size. As the spiral part is not preserved in the present material and the two limbs of U in this specimen looks to be more closely set than in that species, we provisionally call this species *Nostoceras* sp. B, aff. *N. hetonaiense*, until better material is obtained.

It is noted here that two specimens consisting of the spiral part alone (without U-shaped body-chamber) were obtained by M. TANI (MT136 and MT193) from Mitsugawa, Kita-ama Formation of the Izumi Group in the island of Awaji. They can be provisionally called *Nostoceras* (?) sp. cf. *N. hetonaiense* MATSUMOTO.

Occurrence.—Sandy siltstone of the Azenotani Formation at Loc. 4 (Takinoike), which is referable to Horizon A2.

Genus *Neocrioceras* SPATH, 1926

Type-species.—*Crioceras spinigerum* JIMBO, 1894 (from the Santonian of Hokkaido).

Subgenus *Schlueterella* WIEDMANN, 1962

Type-species.—*Ancyloceras pseudoarmatum* SCHLÜTER, 1872.

Remarks.—According to WIEDMANN (1962b, p. 205)), the shell-form of *Schlueterella* is ancyloceratid with open spiral coiling, but the complete shell form of the type-species has not been illustrated.

Pending the clearer redefinition, three fragmentary specimens from Izumi are provisionally reported under this subgenus with a query.

Neocrioceras (*Schlueterella*) (?) sp.

Pl. 16, Figs. 1-2

Material.—SK3 (S. KANEKO's Coll.), MK869 (M. KUWANO's Coll.) and OMNH. M 2125 (coll. by T. NISHIOKA), from Loc. 4 (Takinoike).

Description.—The three specimens are all fragmentary. SK3 keeps subcircular cross-section, with H=30 mm, B=30 mm, but still septate. MK869 is secondarily compressed, whereas OMNH. M2125 is secondarily depressed. They have two rows of fairly large tubercles, which are disposed alternately, and the ribs are looped at the tubercles. Ribs are numerous and of moderate intensity.

MK869 has no dorsolateral tubercles and the ribs cross the dorsum with some backward curvature. On the two other specimens the presence or absence of the dorsolateral tubercles is not well determined, but no distinct ones are discernible.

Suture, partly exposed on SK3, is florid.

Comparison.—The specimens are too incomplete for exact identification. The observed characters remind us of *Schlueterella,* but the typical species of that subgenus have four rows of tubercles (see SCHLÜTER, 1872).

Exiteloceras etequense LEWY (1969, p. 124, pl. 3, fig. 5) and *Idiohamites* (?) *circularis* LEWY (1969, p. 128, pl. 3, fig. 9 ; text-fig. 3), both from the Upper Campanian of Israel, have similar ornamentations to ours, although they are much smaller and evidently show loosely planospiral coiling. These two species and probably also *Idiohamites* (?) *oronensis* LEWY (1969, p. 127, pl. 3, figs. 10-11), from the Upper Campanian of Israel, may represent a new genus which is allied to *Neocrioceras* (*Schlueterella*) but has no dorsolateral tubercles. The present species from the Izumi Group may belong to the same genus. Anyhow, we need more and better material to confirm this idea. Provisionally it is described under the indicated name.

The specimens could be portions of a fairly large shell of *Didymoceras,* in view of their similarity to the hooked body-chamber of *D. hornbyense* (WHITEAVES, 1895) (see USHER, 1952, p. 103, pl. 27, figs. 1-2 ; pl. 28, fig. 2). One of the Izumi specimens, SK3 is, however, still septate at the diameter of 30 mm in whorl-section and its ribs are not so oblique as in the helical part of *Didymoceras.*

Occurrence.—Sandy siltstone of the Azenotani Formation at Loc. 4 (Takinoike), Horizon A2.

Genus *Pseudoxybeloceras* Wright and Matsumoto, 1954

Type-species.—*Hamites quadrinodosus* Jimbo, 1894.

Remarks.—This genus has recently been discussed by Klinger (1976) and Ward and Mallory (1977), whereas Matsumoto (1977) has defined more clearly the type-species from Hokkaido. Although this is not the place to discuss comprehensively the taxonomy and phylogeny, we agree with Klinger (1976, p. 75–76) in regarding *Parasolenoceras* Collignon, 1969 and *Christophoceras* Collignon, 1969 as the subgenera of *Pseudoxybeloceras*. On account of the close affinity between the type-species, *Ps.* (*Cyph.*) *lineatum* (Gabb) and *Chr. ramboulai* Collignon, 1969, the subgenus *Cyphoceras* Ward and Mallory, 1977, falls in the synonymy of the subgenus *Christophoceras* Collignon, 1969.

Subgenus *Parasolenoceras* Collignon, 1969

Type-species.—*P. splendens* Collignon, 1969.

Remarks.—*Parasolenoceras* is distinguished from *Pseudoxybeloceras* (s. s.) by a more elongated and narrower U-form of the shell at a late growth-stage and a pair of ventral tubercles alone on every simple rib.

It is distinguished from *Christophoceras* by the absence of major ribs and that of ventrolateral (i. e., upper lateral) tubercles.

Ps. (*Cyphoceras*) *lineatum* is referred to *Ps.* (*Christophoceras*), whereas *Ps.* (*Cyphoceras*) *nanaimoense* Ward and Mallory to *Ps.* (*Parasolenoceras*).

Pseudoxybeloceras (*Parasolenoceras*) sp.

Pl. 15, Fig. 3

Material.—SK4 (S. Kaneko's Coll.) from Loc. 4 (the cliff on west side of Takinoike).

Description.—This is a deformed, poorly preserved specimen, consisting of two parallel limbs which are closely spaced but not in contact. Numerous ribs are narrow, sharp-headed and provided with a pair of spinose ventral tubercles. They are somewhat prorsiradiate on the earlier limb and nearly vertical on the later one. Suture is unexposed.

Comparison.—This specimen resembles *Ps.* (*Parasolenoceras*) *splendens* (Collignon) (1969, p. 44, pl. 530, figs. 2087–88), from the Lower Campanian of Madagascar, in the general aspects, but the illustrated type-specimen of that species is larger than ours and has a wider space between the two limbs, although the narrow space in ours may be due to the secondary deformation. The tubercles appear to be more spinose in our specimen.

Ps. (*Parasolenoceras*) *nanaimoense* (Ward and Mallory), (1977, p. 615, pl. 2, figs. 1–3; pl. 3, figs. 1–3; text-fig. 3), from the Campanian part of the Nanaimo Group in Vancouver Islands, has as fine and dense ribs as in our specimen but shows a wider space

between the two subparallel shafts. Its ventral tubercles are periodically very long and spinose. Such specially elongated spines are not discernible in the Izumi specimen.

Occurrence.—Very fine sandy siltstone of the Azenotani Formation at Loc. 4 (Takinoike), Horizon A2.

Genus *Solenoceras* CONRAD, 1860

Type-species.—*Hammites annulifer* MORTON, 1842.

Remarks.—This genus has recently been discussed by KLINGER (1976) and WARD and MALLORY (1977), among many others. Majority of authors, including STEPHENSON (1941) and WRIGHT (1957), prefer to suppress *Oxybeloceras* HYATT, 1900 as a synonym of *Solenoceras* CONRAD, 1860, whereas SPATH (1953) and MATSUMOTO (1959 b) maintained *Oxybeloceras*. In this paper we treat *Oxybeloceras* as a subgenus of *Solenoceras*. *Solenoceras* s. l.) ranged from Upper Campanian to Maastrichtian and was widespread.

Subgenus *Oxybeloceras* HYATT, 1900

Type-species.—*Hamites* (*Ptychoceras*) *crassum* WHITFIELD, 1880.

Diagnosis.—Similar to *Solenoceras* (s. s.) in shell-form and ornamentation of the late growth-stage, that has the U-curved and then straightened body-chamber which touch or embraces the next earlier, nearly straight limb. Still earlier shell is J-shaped extended from open-spiral earliest part. Larger than *Solenoceras* (s. s.) and devoid of constrictions. Suture is essentially similar to that of *Pseudoxybeloceras*.

Remarks.—The functional meaning of the constrictions in heteromorph ammonoids is not yet clear. A constriction is normally formed near the apertural end of the shell and its periodic occurrence implies the arrest of growth. Presumably the constriction binded the soft animal body tightly kept in a shell like a fastened band in human being. Therefore the mode of life must be dissimilar between the ammonites with frequent constrictions and that without them (or with only one at the very apertural end).

Phylogenetically *Solenoceras* (s. l.) is generally considered as having been derived from *Pseudoxybeloceras* (s. l.). The latter is generally larger than *Solenoceras* at the adult stage and has no constriction. In this respect *Oxybeloceras* represents a transitional stage of this evolutionary change.

Based on the finely preserved examles of *Pseudoxybeloceras* (i. e., *Ps.* (*Parasolenoceras*) *nanaimoense*), WARD and MALLORY seem to be convinced of the derivation of *Solenoceras* (s. s.) from this kind of species, which, according to their restoration, has several straight (or nearly straight) limbs connected by U-curved parts at several times. (The very initial part is unknown even in their examples.)

An interesting example of *Solenoceras humei* (DOUVILLE), illustrated by LEWY (1967, p. 170, pl. 3, figs. 1-3), shows a gyroconic spire at the early stage, followed by a J-shap-

ed part which, in turn, extends to the earlier straight limb of the closed U. This species is somewhat larger than the typical species of *Solenoceras* (s. s.) and has no perceptible constriction. Therefore, it is referred to the subgenus *Oxybeloceras* of the above definition. The early shell-form of *Oxybeloceras* seems to have some common with that of *Pseudoxybeloceras* (s. s.), which has a J-shaped stage. We are looking for a still earlier part of *Pseudoxybeloceras*.

Based on the above observation, we think it too hasty to suppress *Oxybeloceras*. In the present situation, it is better to retain *Oxybeloceras* as a subgenus of *Solenoceras*.

Solenoceras (*Oxybeloceras*) sp. A
aff. *S.* (*O.*) *crassum* (WHITFIELD)
Pl. 15, Fig. 1

Compare.—

1880. *Ptychoceras crassum* WHITFIELD, *U. S. Geol. Geogr. Surv., Rocky Mts. Region* (1877), p. 450, pl. 16, figs. 3-6.

Material.—OMNH. M1157 (no record of collector), from Loc. 4 (Takinoike).

Description.—This is a fragmentary specimen of U-curved part, with the last septum at its posterior end. The whorl is nearly as broad as high, about 9 mm at the preserved anterior end. Small empty space remains inside the curved portion.

The shell is ornamented with coarse and sharp-headed ribs and a pair of prominent ventral tubercles. The ribs are prorsiradiate on the earlier part and rursiradiate on the later part. Occasionally a fine rib without tubercle is intercalated between the normal ones.

Suture of the last septum is partly exposed, showing fairly narrowed stems of the elements.

Comparison.—The observed characters remind us of *S.* (*O.*) *crassum* (WHITFIELD), from the Campanian Pierre Shale of the U. S. Western Interior province. In that species the siphonal zone between the ventral tubercles is recorded as concave, but in our specimen it is simply flat. There is no intercalated minor rib in *S.* (*O.*) *crassum*.

Probably this specimen represents a new species of *Solenoceras* (*Oxybeloceras*), which is allied to *S.* (*O.*) *crassum*, but the present material is too poor to establish a new species.

Occurrence.—Azenotani Formation at Loc. 4 (Takinoike), Horizon A2.

Subgenus *Solenoceras* CONRAD, 1860

Solenoceras (*Solenoceras*) sp. B
aff. *S.* (*S.*) *reesidei* STEPHENSON
Pl. 15, Fig. 2

Compare.—

1941. *Solenoceras reesidei* STEPHENSON, *Univ. Texas Publ.* (4101), p. 401, pl. 77, figs. 1-3.

Material.—MK871 (M. KUWANO's Coll.), from Loc. 2 (Azenotani).

Description.—This is a small fragmentary U-shaped shell (internal mould), with the last septum at its posterior end. The body-chamber is depressed secondarily (?), with H=5 mm, B=7.5 mm, and embraces much smaller earlier limb (whose dorsal embraced portion alone is preserved). A minute empty space is discernible inside of the U-curve.

Shell is ornamented with fine and fairly dense simple ribs, each of which has a pair of ventral tubercles up to the U-curved portion, but the tubercles are weakened and seemingly lost on of the main straight part of the body-chamber. The ribs are rursiradiate near the U-curved part in the last shaft, becoming less so later.

There is a distinct constriction at the U-curved part in front of the last septum.

Comparison.—This specimen is similar to *S.* (*S.*) *reesidei* STEPHENSON, from the Neylandville Marl and the Nacatoch Sand of the Navarro Group, but is different in the weakening of ventral tubercles on the late part of the body-chamber.

Occurrence.—Fine sandy siltstone of the Azenotani Formation at Loc. 2 (Azenotani), Horizon A2.

Genus *Exiteloceras* HYATT, 1894

Type-species.—*Ancyloceras jenneyi* WHITFIELD, 1880.

Remarks.—LEWY (1969, p. 122) has given a generic diagnosis based on the material from Israel. This is useful, but we hesitate to include *E. etequense* LEWY in the same genus (see discussions about *Neocrioceras* (*Schlueterella*) (?) sp.). The group of species which we have written as suggesting a new genus may be closely related to typical *Exiteloceras* or otherwise.

GILL and COBBAN (1973) have shown a reconstructed illustration of *E. jenneyi,* from the Upper Campanian of the Western Interior province (North America), but did not discuss much on the relations of *Exiteloceras* with other genera in that stratigraphic paper. The material from the Izumi Group it too poor to settle the problem. It is described provisionally under this genus with a query.

Exiteloceras (?) sp.

Pl. 15, Fig. 4

Material.—Two fragmentary specimens, MK868 (M. KUWANO's Coll.) and SK5 (S. KANEKO's Coll.), consisting of several pieces, from Loc. 4 (Takinoike), and MK870 (M. KUWANO's Coll.), from Loc. 3 (Showaike).

Description.—The three specimens are too fragmentary to restore the entire shell

form, but they suggest a gently curved shape rather than a straight shaft. It is sub-elliptical in section, with H=51.5, B=45.0 mm in MK868.

The shell has strong, sharp-headed ribs, which are separated by interspaces slightly broader than the ribs. Each rib is provided with a pair of ventral tubercles. The ribs are mostly simple and cross the dorsum with some weakening and approximation. On MK868 and SK5 there are a few intercalatory ribs. All the ribs are somewhat rursiradiate (?) on the flank. The tubercles are shortly spinose.

The specimens have no septum and are probably pieces of the body-chamber.

Comparison.—The specimens are too fragmentary for the precise identification even at generic level. On the basis of the resemblance to the later part of *Exiteloceras jenneyi* (WHITFIELD) (1880, p. 452, pl. 16) from the Upper Campanian of Wyoming, a provisional reference to that genus is suggested, but this is by no means certain. They are larger than the WHITFIELD's specimen.

Occurrence.—Fine sandy siltstone of the Azenotani Formation at Loc. 3 (Showaike) and Loc. 4 (Takinoike), Horizon A2.

Family Diplomoceratidae SPATH, 1926

We would not discuss here comprehensively the scope of this family (subfamily according to some authors), but generally follow MATSUMOTO (1977, p. 347), in which the definition by WRIGHT (1957, p. L224-L228) has been revised to some extent.

Genus *Diplomoceras* HYATT, 1900

Type-species.—*Hamites cylindraceus* DEFRANCE, 1822.

Diplomoceras sp. cf. *D. notabile* (WHITEAVES)

Pl. 16, Fig. 3

Compare.—

1903. *Diplomoceras notabile* WHITEAVES, *Mesozoic Fossils* 1, pl. 5 ; p. 335, pl. 44, fig. 4.

1952. *Diplomoceras notabile* : USHER, *Geol. Surv. Canada, Bull.* (21), p. 109, pl. 29, fig. 2 ; pl. 30, fig. 1 ; pl. 31, figs. 26-27.

Material.—SK7 (S. KANEKO's Coll.) from Loc. 2 (Azenotani).

Description.—This specimen is fairly large. Although the precise position of the last septum is not ascertained, the last shaft, as long as 300 mm or more, seems to belong to the body-chamber. The shell is somewhat deformed but seemingly elliptical, rather than circular, in cross-section, being higher than broad.

The shell is ornamented with numerous, dense simple ribs, about 14-17 within the distance of height (i. e., longer diameter), which are vertical to the axis of growth.

Unfortunately the details of the suture-line are unexposed.

Comparison.—This specimen looks very similar to one of the specimens (USHER, 1952, pl. 30, fig. 1) of *D. notabile* and its last straight shaft is also very similar to the holotype (GSC. No. 10064) (plaster cast GK. H9568), from the Upper Lambert Formation of the Nanaimo Group (British Columbia). As the details of the suture, as figured by USHER (1952, pl. 31, figs. 26-27) and SPATH (1953, pl. 2, fig. 4), are not known in this specimen, we hesitate to conclude the perfect specific identity and call it provisionally *Diplomoceras* sp. cf. *D. notabile* (WHITEAVES).

Occurrence.—Sandy siltstone of the Azenotani Formation at Loc. 2 (Azenotani), Horizon A2.

Family Baculitidae MEEK, 1876

Genus *Baculites* LAMARCK, 1799

Type-species.—*Baculites vertebralis* DEFRANCE, 1830.

Baculites regina OBATA and MATSUMOTO

1963. *Baculites regina* OBATA and MATSUMOTO, *Mem. Fac. Sci., Kyushu Univ., Ser. D,* 13(1), p. 85, pl. 22, figs. 3-6 ; pl. 23, figs. 1-2 ; pl. 24, figs. 1-5 ; pl. 25, figs. 3-5 ; pl. 27, figs. 1, 6, 7, 9 ; text-figs. 191-196, 200-214.

Remarks.—This was described by OBATA and MATSUMOTO, 1963 (see above) on a large number of specimens, which are, however, mostly incomplete. No material of subsequent collection is available for us. We put up here the specific name merely for completing the described species from the Izumi Mountains. The localities of the individual specimens were recorded by OBATA and MATSUMOTO. They are sorted into Locs. 1, 2 and 4 in terms of the locations indicated in this paper. They all belong to the Azenotani Formation and are referred to Horizon A2.

Baculites sp.

Material.—OMNH. M2148 (coll. by Y. MOROZUMI) from Loc. 8 (northeast of Sobura).

Descriptive remarks.—This shows a subelliptical cross-section (with H=16.0, B=12.0 mm), with slow tapering and without showing suture. It is so poorly preserved that the specific identification is impossible. It is recorded here for further hunting better material.

Occurrence.—In a calcareous nodule at Loc. 8 (Sobura), Horizon B5.

Family Scaphitidae MEEK, 1876

Genus *Hoploscaphites* NOWAK, 1911

Type-species.—*Scaphites constrictus* J. SOWERBY, 1817.

Remarks.—As BIRKELUND (1965) mentioned, it may be better to treat *Hoploscaphites* as a subgenus of *Scaphites*. We have no material to discuss the status of *Hoploscaphites* and temporarily use it as a generic name merely for brevity.

Hoploscaphites (?) sp.
Pl. 15, Fig. 5

Material.—MT42 (M. TANI's Coll.), from Loc. 7 (Sobura).

Description.—This is poorly preserved, consisting mainly of the living-chamber and a portion of the septate part. The living chamber is 82 mm long; it is compressed with H=36.0, B=21.0 mm (B/H=0.58) at its middle part; its venter is narrowly arched; shaft is comparatively short.

The surface of the living chamber is ornamented with rather weak, somewhat irregular, more or less gently flexuous ribs and several indistinct clavi at the ventrolateral part of the earlier half. On the later half of the living chamber the major ribs are much weakened and flattened. There may be fine lirae in addition to the major ribs, but they are not well shown, being only partially discernible.

Comparison.—This is too poorly preserved even for generic identification. Indication of it under *Hoploscaphites* (?) sp. is tentative.

NOWAK (1911) has shown a great extent of variation in *Hoploscaphites constrictus*, of which the form described under *H. constrictus* var. *vulgaris* NOWAK (1911, p. 583, pl. 32, fig. 6; pl. 33, figs. 8-12) seems to include an example (pl. 33, fig. 8) which is somewhat similar to our specimen. NOWAK, however, recorded the presence of the umbilical tubercles on the body-chamber in addition to more distinct ventrolateral tubercles.

This specimen is not referable to *Indoscaphites* SPATH, 1953, because *I. cunliffei* (FORBES), the type-species, as represented by BM.(NH). C 51090 〔=FORBES, 1846, pl. 8, fig. 2〕, is characterized by distinct bituberculation appearing from earlier stage and a flattened venter.

Concluding Remarks

The main conclusions of this work are summarized below, with some discussions.

(1) The ammonite species from the Upper Cretaceous of the Izumi Mountains described in this paper are listed in Table 3. Of the 18 species 7 belong to the families Phylloceratidae, Pachydiscidae, Gaudryceratidae and Tetragonitidae, whereas the rest 11 are heteromorpha of the Nostoceratidae, Diplomoceratidae, Baculitidae and Scaphitidae. There is no representative of the Acanthocerataceae nor Hoplitaceae.

(2) This implies that the elements of the ammonite faunas at family and also generic

Table 3. List of ammonites from the Upper Cretaceous of the Izumi Mountains

Specific name \ Horizon / Locality	A2					B3	B5		
	1	2	3	4	5	9	6	7	8
1. *Hypophylloceras* (*Neophylloceras*) sp. cf. *H.* (*N.*) *hetonaiense* MATSUMOTO				•		•		●	
2. *Canadoceras tanii* sp. nov.				•					
2′. *C.* sp. cf. *C. tanii* sp. nov.						●			
3. *Pachydiscus* (*Pachydiscus*) *kobayashii* (SHIMIZU)	•	•							
3′. *P.* (*P.*) sp. cf. *P.* (*P.*) *kobayashii* (SHIMIZU)		●	•			•			
4. *P.* (*P.*) sp. aff. *P.* (*P.*) *flexuosus* MATSUMOTO								•	
5. *P.* (*Neodesmoceras*) sp. cf. *P.* (*N.*) *gracilis* MATSUMOTO							•	●	●
6. *Gaudryceras izumiense* sp. nov.					•			●	
6′. *G.* sp. cf. *G. izumiense* sp. nov.						•			
7. *Pseudophyllites* (?) sp.		•							•
8. *Nostoceras* sp. A, aff. *N. kernense* (ANDERSON)								•	
9. *N.* sp. B, aff. *N. hetonaiense* MATSUMOTO				•					
10. *Neocrioceras* (*Schlueterella*) (?) sp.				●					
11. *Pseudoxybeloceras* (*Parasolenoceras*) sp.				•					
12. *Solenoceras* (*Oxybeloceras*) sp. A, aff. *S.* (*O.*) *crassum* (WHITFIELD)				•					
13. *S.* (*Solenoceras*) sp. B, aff. *S.* (*S.*) *reesidei* STEPHENSON		•							
14. *Exiteloceras* (?) sp.			•	•					
15. *Diplomoceras* sp. cf. *D. notabile* WHITEAVES		•							
16. *Baculites regina* OBATA and MATSUMOTO	•	●		●					
16′. *B.* sp. cf. *B. regina* OBATA and MATSUMOTO		●							
17. *B.* sp.									•
18. *Hoploscaphites* (?) sp.								•	

● : more than 3 specimens, • : 1 or 2 specimens

levels are similar to those of the Hetonaian (approximately Campanian-Maastrichtian) of Hokkaido and that they probably represent an outer neritic biofacies.

(3) Most of the described ammonites occur in fine-sandy siltstone above the basal conglomerate of the Izumi Group and a few in coarse clastics of the main turbidite facies. Despite the proximity of that siltstone to the northern margin of the distributional belt of the Izumi Group, the sediments are not of the littoral facies but referable to the neritic facies of moderate depth, as suggested by the contained ammonites (see above). It should be noted that many of the described ammonites represent the adult

shells, having the body-chamber.

A rare occurrence (at one locality) of fragmentary specimens in a conglomerate bed of turbidite facies may imply that they were retransported by turbidity currents from some more fossiliferous sediments of the same or somewhat older age. Despite the narrowly elongated outcropping area of the Izumi Group, the sediments were not formed in an inland sea basin but probably accumulated in a trough under an open sea.

(4) The well defined species, among others, are *Canadoceras tanii* sp. nov., *Pachydiscus* (*Pachydiscus*) *kobayashii* (SHIMIZU), *Gaudryceras izumiense* sp. nov. and *Baculites regina* OBATA and MATSUMOTO. For some reasons, they are particular to the Izumi Mountains and have not yet been confirmed to occur in other areas, home and abroad. This may be explained by a concept of faunal provincialism, but could also be ascribed to some difference in age between the fossiliferous formations to be compared with each other.

(5) There is unmistakable distinction between the faunas of the two fossiliferous horizons, A2 and B5. Horizon A2 is characterized by *Pachydiscus* (*Pachydiscus*) *kobayashii, Canadoceras tanii* and *Baculites regina,* whereas Horizon B5 by *Pachydiscus* (*Pachydiscus*) aff. *flexuosus, P.* (*Neodesmoceras*) cf. *gracilis* and *Gaudryceras izumiense.* The last species is, however, rarely found from a locality within A2 and also fragmentarily from a turbidite bed referable to B3.

Among the species which are represented by incompletely preserved specimens, *Nostoceras* aff. *kernense* and *Hoploscaphites* (?) sp. are, so far, particular to B5, while many other heteromorph species (listed under 9–15) are from A2.

(6) As has been recently described by MATSUMOTO et al. (1979), *Pachydiscus* (*Pachydiscus*) *flexuosus* and *P.* (*Neodesmoceras*) *gracilis* occur characteristically in the upper part of the Hetonaian [K6b2] of Hokkaido, which can be indirectly correlated with the Maastrichtian of international scale. Therefore, Horizon B5 of the Izumi Group is most probably assigned to the Maastrichtian.

(7) The age of Horizon A2 of the Izumi Group is not determined exactly on the grounds of the described ammonite species, because they are either endemic or long ranging. Affinities with certain species from the Campanian of Madagascar and North America are indicated by *Canadoceras tanii, Pachydiscus* (*Pachydiscus*) *kobayashii, Pseudoxybeloceras* (*Parasolenoceras*) sp., *Solenoceras* (*Oxybeloceras*) aff. *crassum* and *Diplomoceras* cf. *notabile,* but they are by no means distinctive inasmuch as the specific identity is denied or uncertain. The genera *Pseudophyllites, Nostoceras, Solenoceras* and *Diplomoceras* range from Upper Campanian through Maastrichtian of current usage, as does *Hypophylloceras* (*Neophylloceras*) *hetonaiense. Gaudryceras izumiense* is more characteristic to Horizon B5 but rarely occurs also at Horizon A2.

To sum up, the ammonites from A2 suggest the age of the latest Campanian or near the boundary of Campanian and Maastrichtian. Such an age was concluded by

JONES (1963) for the Zone of *Pachydiscus kamishakensis* of the Matanuska Formation in southern Alaska and the *Nostoceras hornbyense* Zonule in the Nanaimo Group (MULLER and JELETZKY, 1970 ; WARD, 1978). There are, however, only a few species which occur commonly between the fossiliferous members in question. Furthermore, how to determine the Campanian-Maastrichtian boundary in the stratotype sequences has not yet been firmly settled. Anyhow, more material is needed to determine precisely the age of Horizon A2.

(8) That the fossiliferous siltstone (called the Azenotani Formation) is diachronous, becoming younger toward the east, is clearly shown by the ammonite faunas of A2 and B5 in addition to the field evidence of stratigraphy. It could be expected that the fossiliferous shale on the basal conglomerate in the island of Awaji and northern Shikoku may be older than that in the Izumi Mountains. To prove this, the available material is insufficient and we need the restudy of ammonites from those areas.

(9) Faunas other than ammonites, such as inocerami, trigonians, other bivalves, echinoids, etc., should be restudied to know more precisely the age and the environments of the Izumi Group. In addition to the works of some groups of bivalves by ICHIKAWA and MAEDA (1958a, b ; 1963 ; 1966), we hope these studies would be carried on by specialists in respective biological groups.

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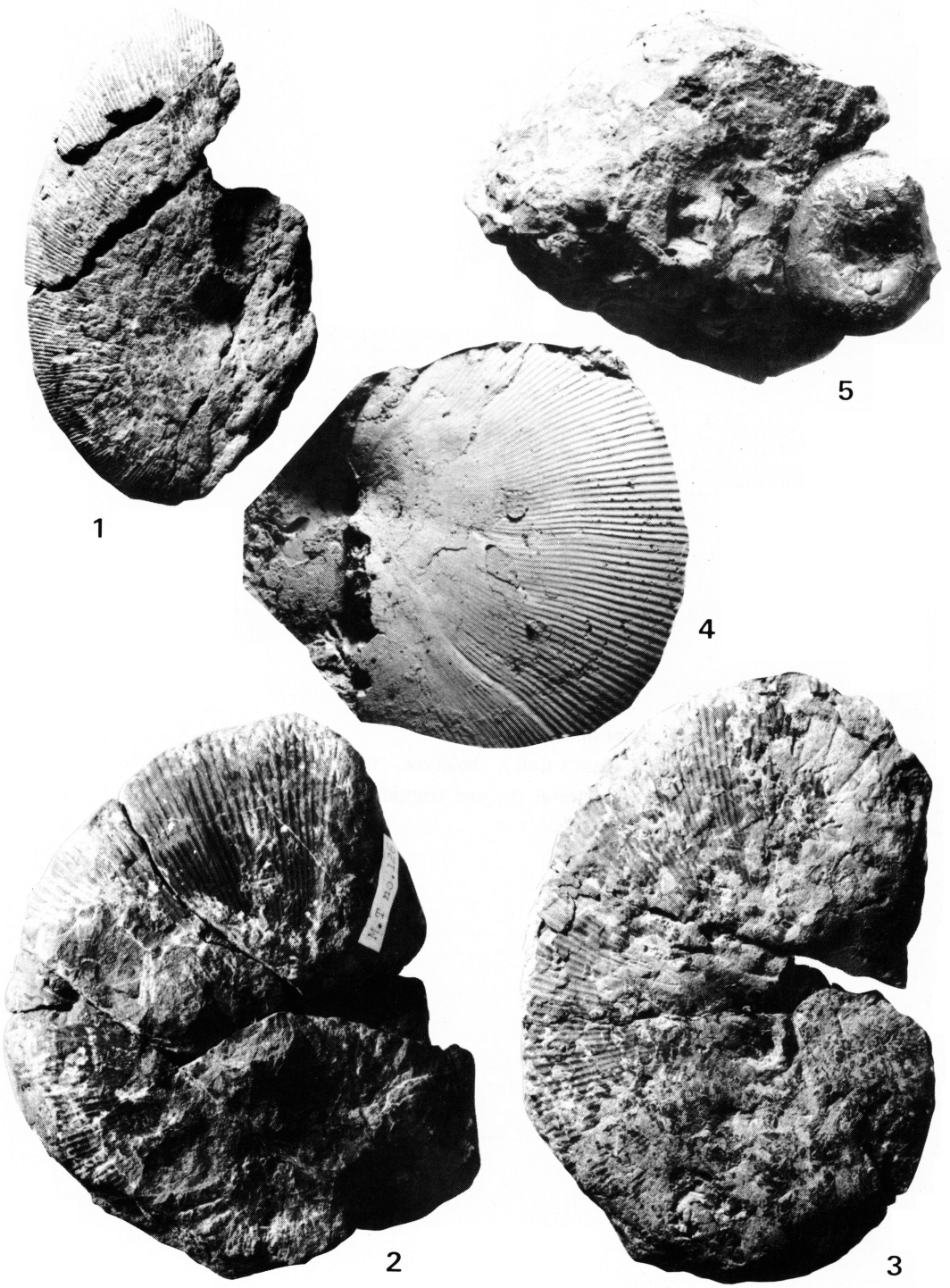
Hakobuchi (函淵), Hakotsukuri (箱作), Hannan-cho (阪南町), Hetonai (辺富内),
Iimoriyama (飯盛山), Iwade (岩出), Izumi (和泉), Izumisano (泉佐野),
Kada (加太), Kaizuka (貝塚), Kasayama (笠山), Kinyuji (金熊寺),
Kita-ama (北阿万), Kokawa (粉河), Kuradani (倉谷), Kyoshi (孝子),
Matsuyama (松山), Misaki (岬), Mitsugawa (三ツ川), Mutsuo (六尾),
Nakanotani (中谷), Nate (名手), Negoro (根来), Sansaka (山坂),
Sennan-gun (泉南郡), Shigo (四郷), Shindachi (信達), Shinike (新池),
Showaike (昭和池), Sobura (薗原), Suberidani (スベリ谷), Takakurayama(高倉山),
Takihata (滝畑), Takinoike (滝ノ池), Tomiuchi (富内), Tomogashima (友ケ島),
Tsuzurahata (葛畑), Urakawa (浦河), Wakayama (和歌山), Warazuhata (童子畑)

Explanation of Plate 1

Figs. 1-4. *Hypophylloceras* (*Neophylloceras*) sp.
cf. *H.* (*N.*) *hetonaiense* MATSUMOTO

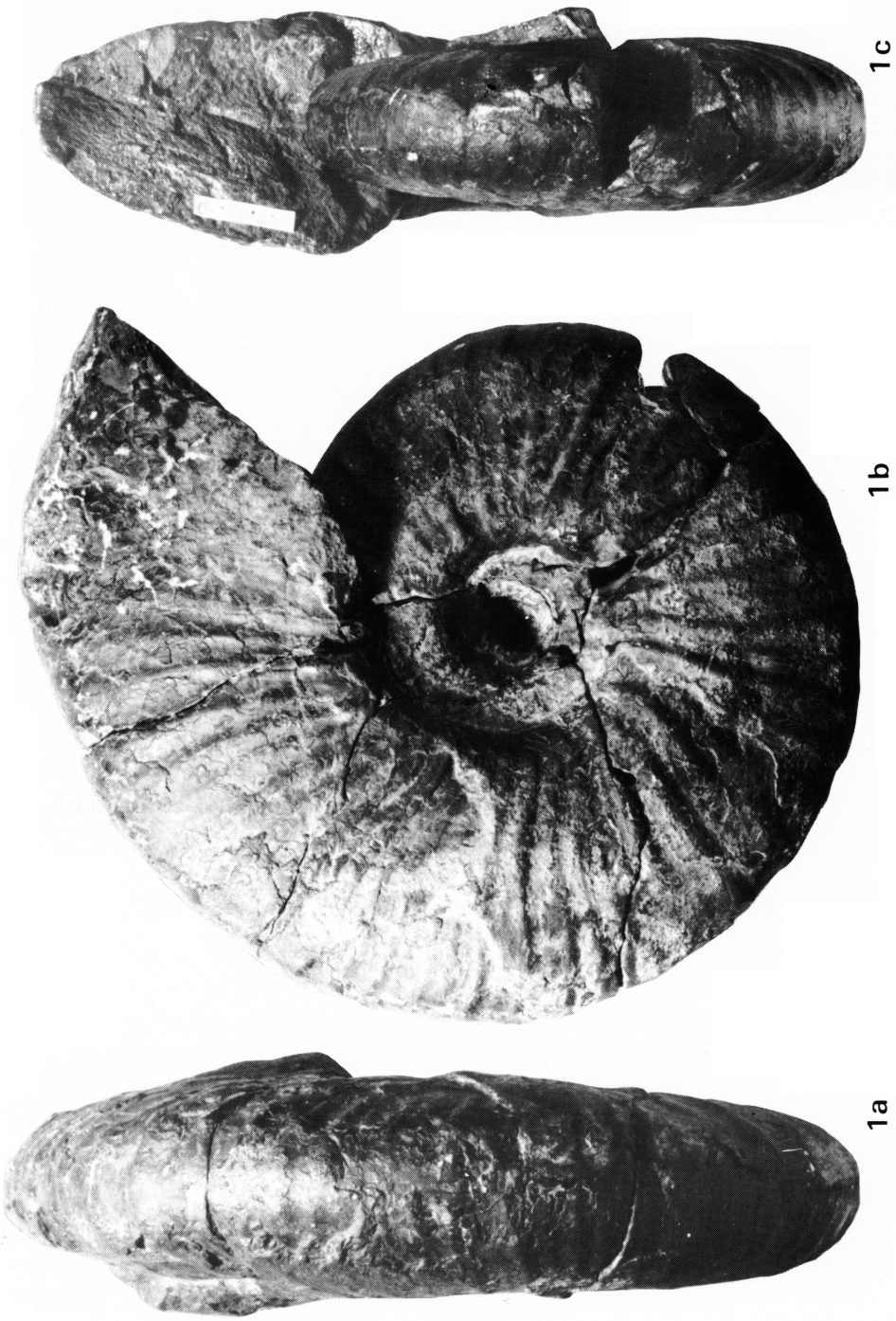
1. Lateral view of MT148 (M. TANI's Coll.), from Loc. 7 (Sobura), ×2/3.
2. Lateral view of MT126 (M. TANI's Coll.), from Loc. 7 (Sobura), ×2/3.
3. Lateral view of OMNH. M2123 (coll. by T. NISHIOKA), from Loc. 7 (Sobura), ×2/3.
4. SK1 (S. KANEKO's Coll.), from Loc. 4 (Takinoike). Lateral view of a rubber cast taken from the external mould, ×1.

Fig. 5. *Pseudophyllites* (?) sp.
Lateral view of an immature specimen, JM20(J. MIYAMOTO's Coll.), from Loc. 8 (Sobura), ×1.


1
2
3
4
5

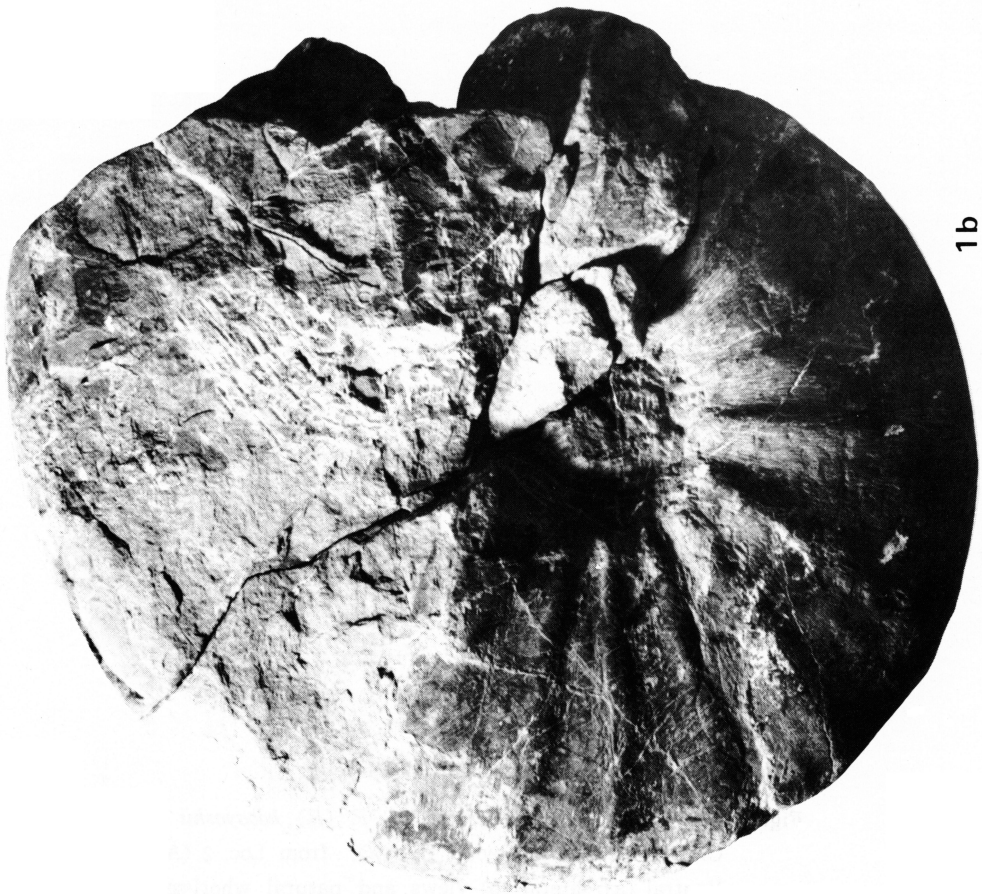
Explanation of Plate 2

Fig. 1. *Canadoceras tanii* sp. nov.
MT80 (M. TANI's Coll.), holotype, from Loc. 4 (Takinoike).
Ventral (a), lateral (b) and frontal (c) views, ×2/3.

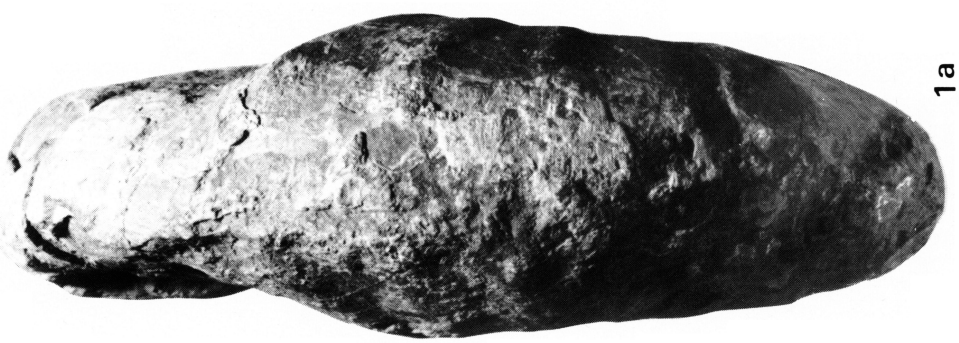

1c
1b
1a

Explanation of Plate 3

Fig. 1. *Pachydiscus* (*Pachydiscus*) *kobayashii* (SHIMIZU)
OMNH. M1068 (coll. by M. FUJITA), from Loc. 2 (Azenotani).
Ventral (a) and lateral (b) views, ×1/2.



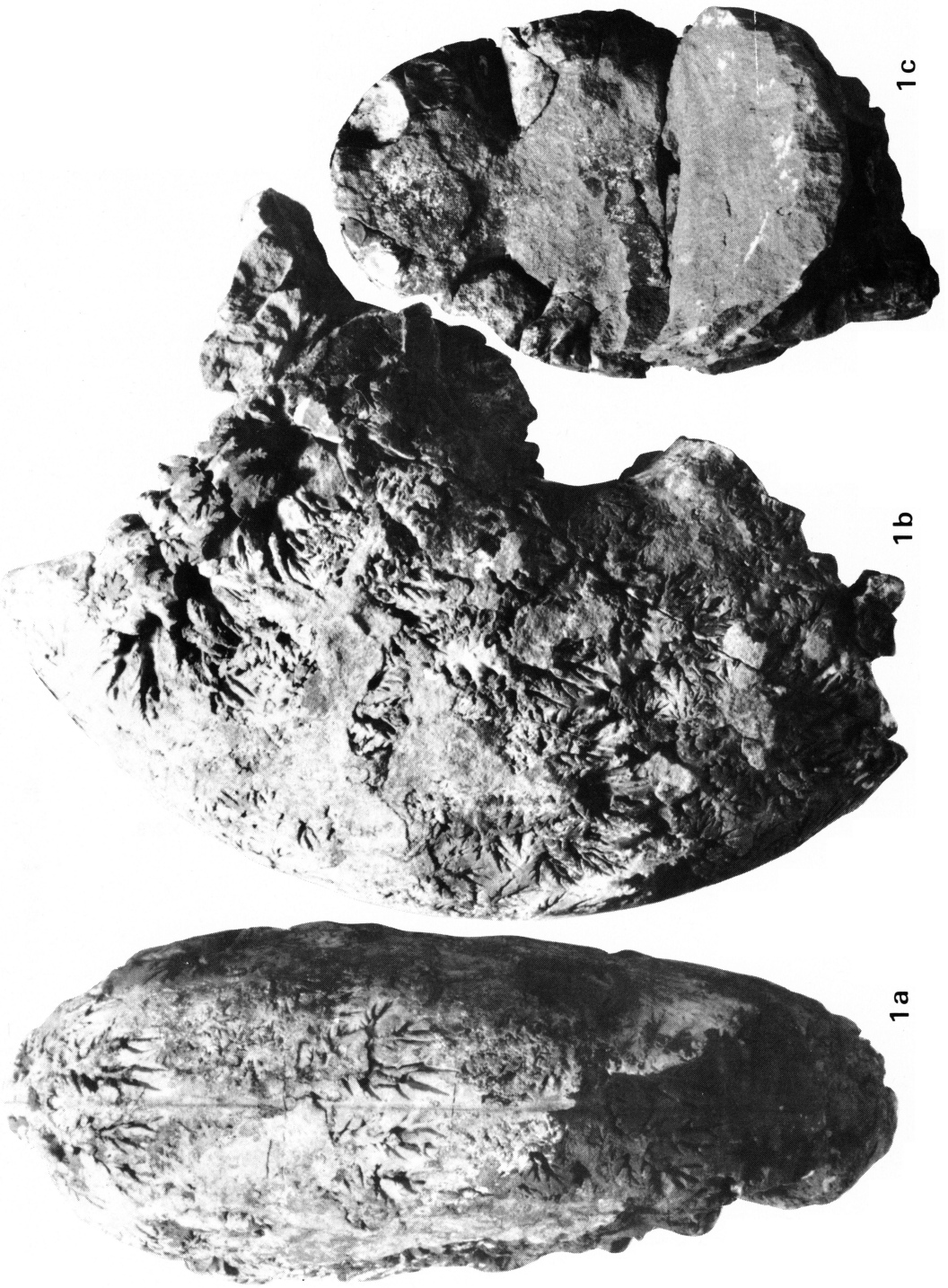
1b



1a

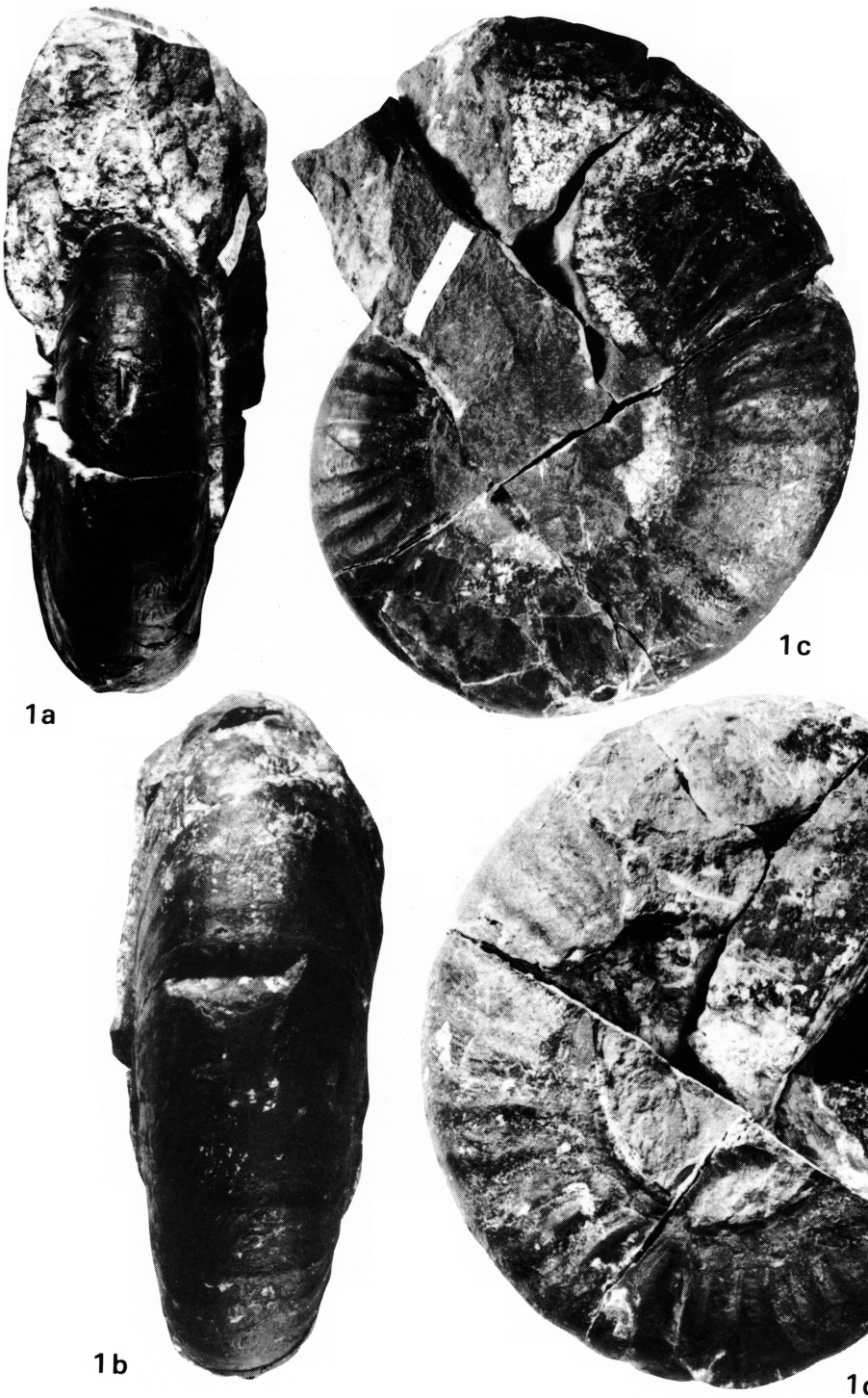
Explanation of Plate 4

Fig. 1. *Pachydiscus* (*Pachydiscus*) sp. cf. *P.* (*P.*) *kobayashii* (SHIMIZU) OMNH. M1070 (coll. by M. FUJITA), from Loc. 2 (Azenotani). Ventral (a), lateral (b) views and natural whorl-section (c), ×2/3.


1c
1b
1a

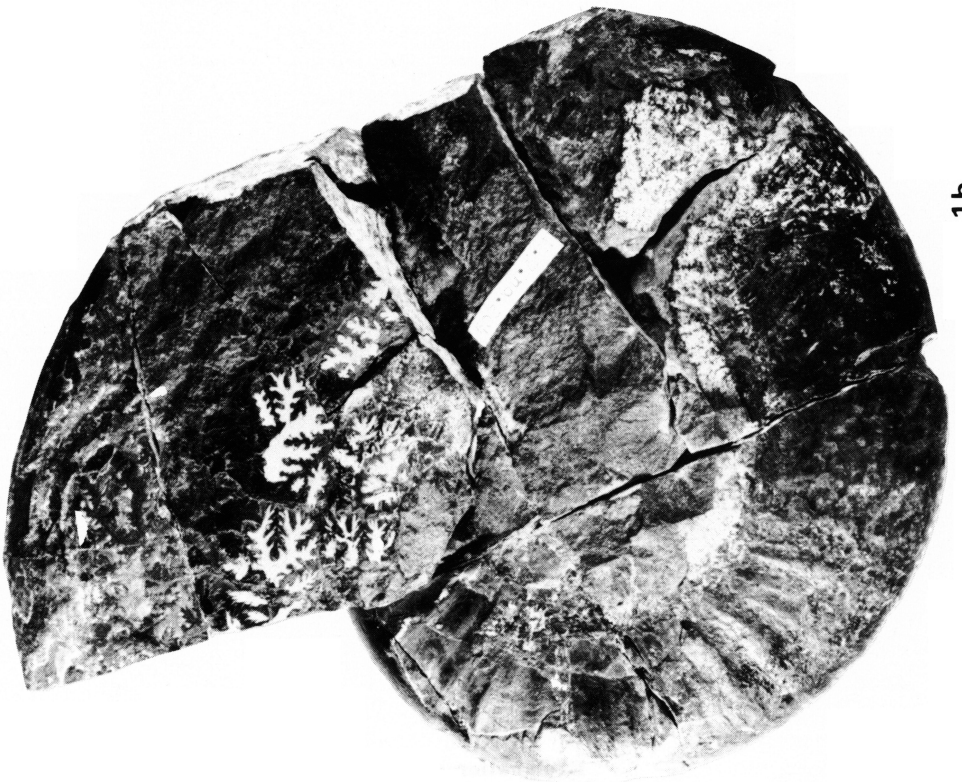
Explanation of Plate 5

Fig. 1. *Pachydiscus* (*Pachydiscus*) sp. aff. *P.* (*P.*) *flexuosus* MATSUMOTO MT204 (M. TANI's Coll.) (excluding the last part, about 90°), from Loc. 7 (Sobura).
Frontal (a), ventral (b) and two lateral (c, d) views, ×2/3.

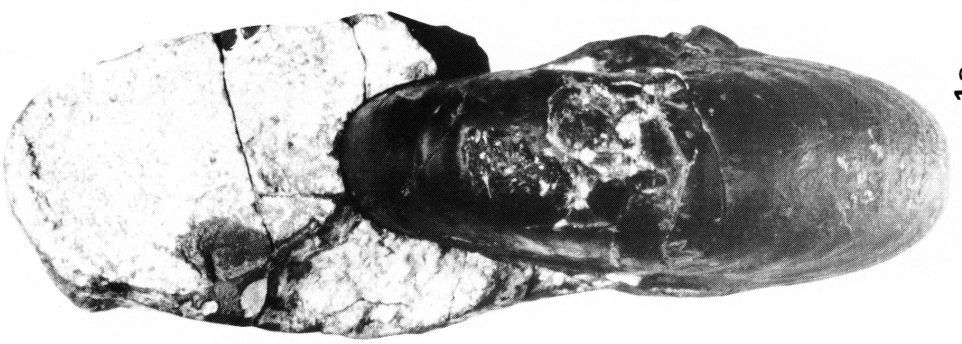

1a
1b
1c
1d

Explanation of Plate 6

Fig. 1. *Pachydiscus* (*Pachydiscus*) sp. aff. *P.* (*P.*) *flexuosus* MATSUMOTO MT204 (M. TANI's Coll.), from Loc. 7 (Sobura).
Frontal(a) and lateral(b) views, ×2/3 (The last part excluded from Pl. 5, Fig. 1 is added here).



1b



1a

Explanation of Plate 7

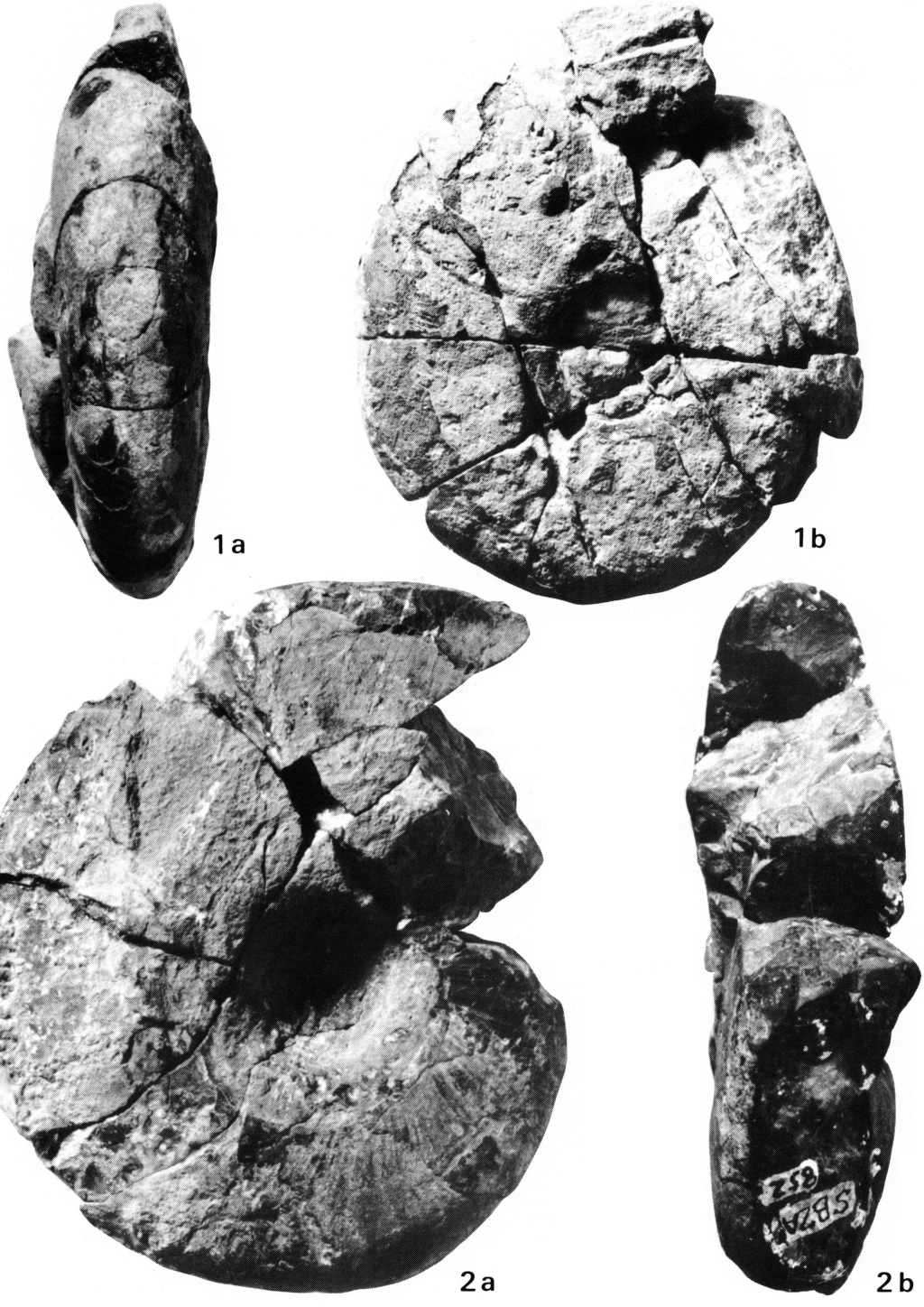
Fig. 1. *Pachydiscus* (*Pachydiscus*) sp. aff. *P.* (*P.*) *flexuosus* MATSUMOTO
Lateral view of another example, MT70 (M. TANI's Coll.), from Loc. 7 (Sobura), ×2/3.


1

Explanation of Plate 8

Figs. 1-2. *Pachydiscus* (*Neodesmoceras*) sp. cf. *P.* (*N.*) *gracilis* MATSUMOTO

1. MT280 (M. TANI's Coll.), from Loc. 7 (Sobura).
   Ventral (a) and lateral (b) views, ×1.
2. MK852 (M. KUWANO's Coll.), from Loc. 6 (Sobura).
   Lateral (a) and frontal (b) views, ×1.


1a
1b
2a
2b

Explanation of Plate 9

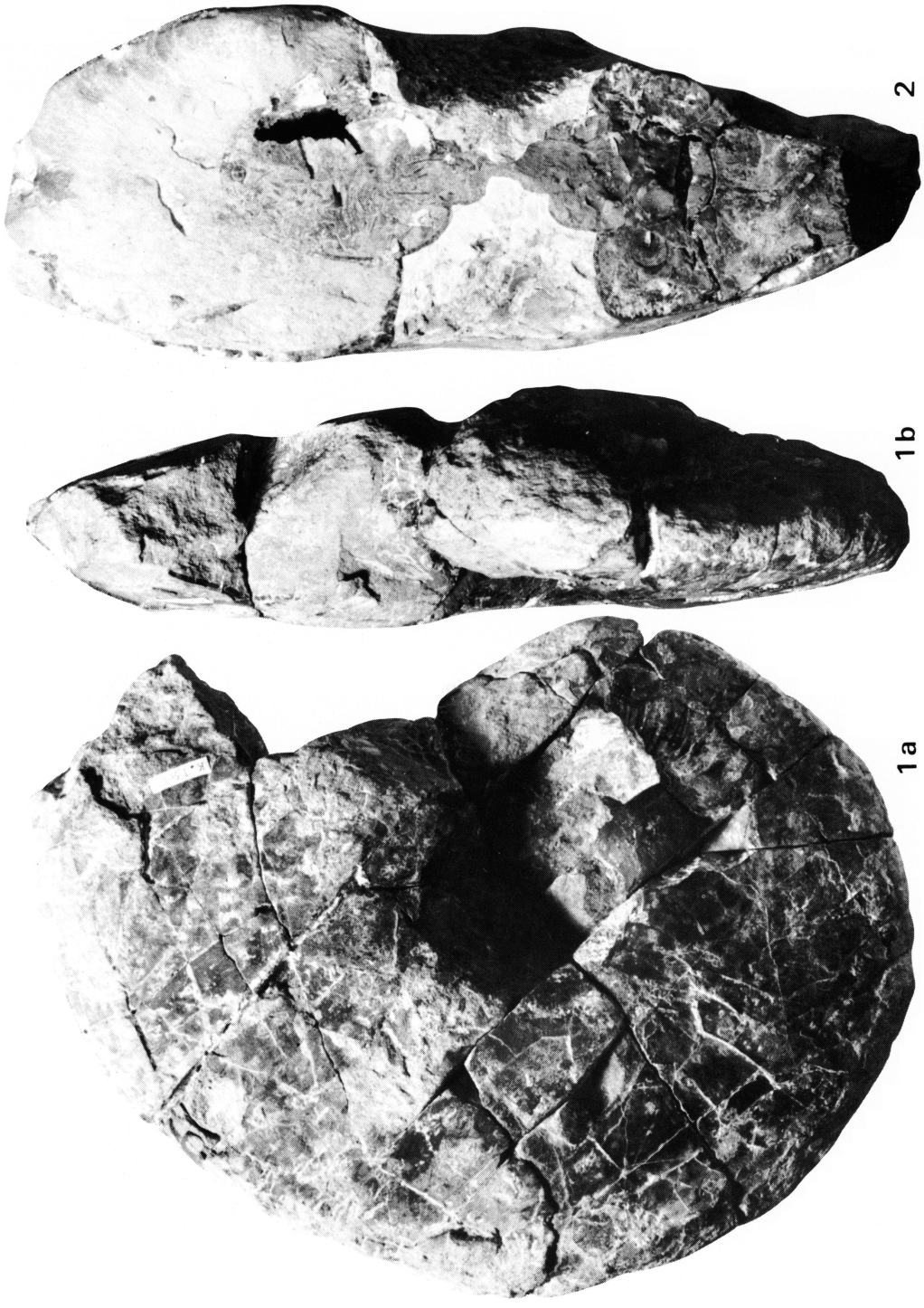
Fig. 1. *Pachydiscus* (*Neodesmoceras*) sp. cf. *P.* (*N.*) *gracilis* MATSUMOTO
OCU. MM774 (coll. by K. YOSHIMURA), from Loc. 7 (Sobura).
Frontal (a), lateral (b) and ventral (c) views of a secondarily compressed specimen, ×2/3.


1c
1b
1a

Explanation of Plate 10

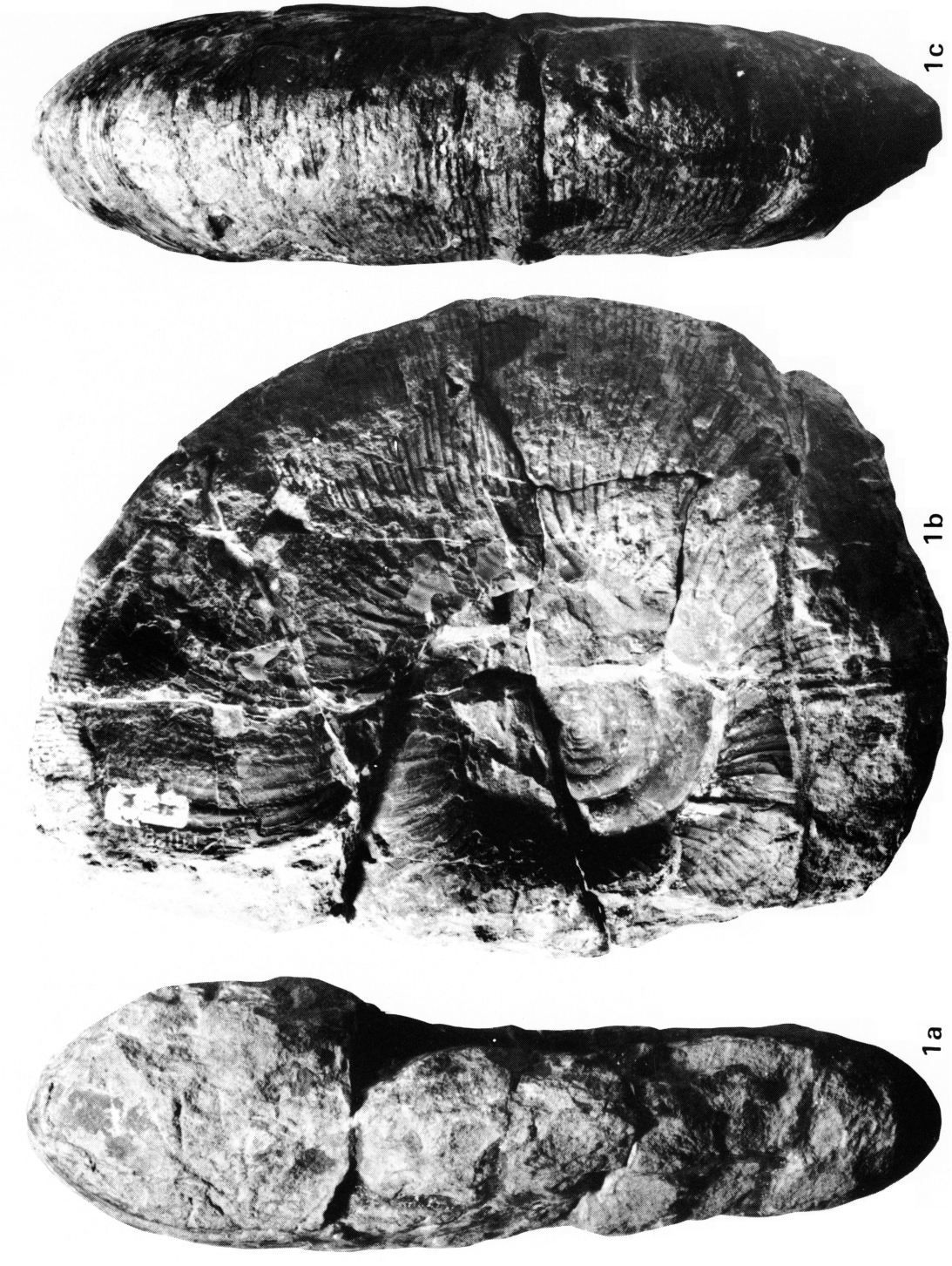
Figs. 1–2. *Pachydiscus* (*Neodesmoceras*) sp. cf. *P.* (*N.*) *gracilis* MATSUMOTO

1. MT102 (M. TANI's Coll.), from Loc. 7 (Sobura).
   Lateral (a) and frontal (b) views of a fairly compressed specimen, ×1/2.
2. Natural whorl-section of JM19 (J. MIYAMOTO's Coll), from Loc. 8 (Sobura), ×2/3.


2
1b
1a

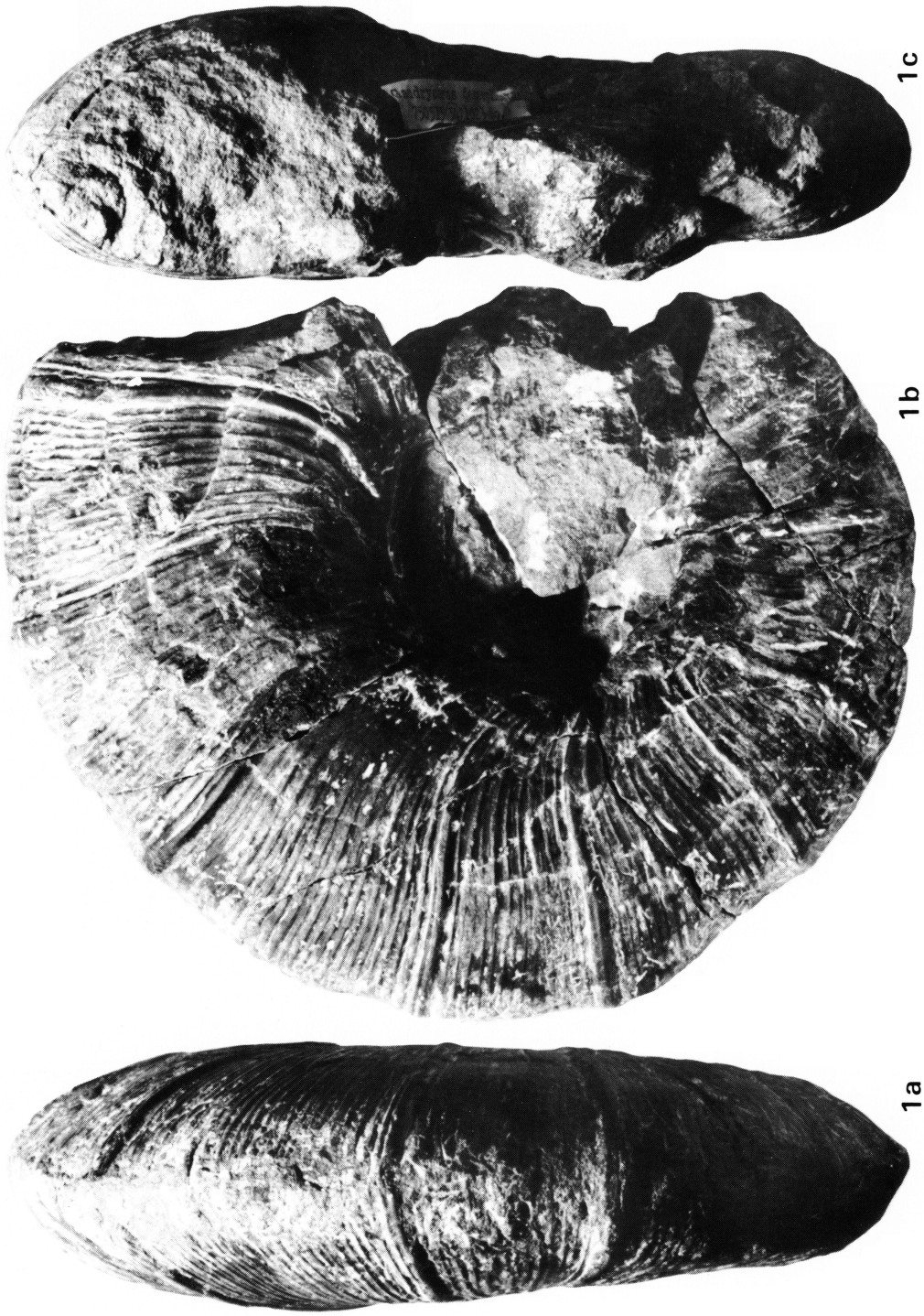
Explanation of Plate 11

Fig. 1. *Gaudryceras izumiense* sp. nov.
OMNH. M1125 (coll. by M. CHIJI), holotype, from Loc. 7 (Sobura).
Frontal (a), lateral (b) and ventral (c) views, ×2/3.


1c
1b
1a

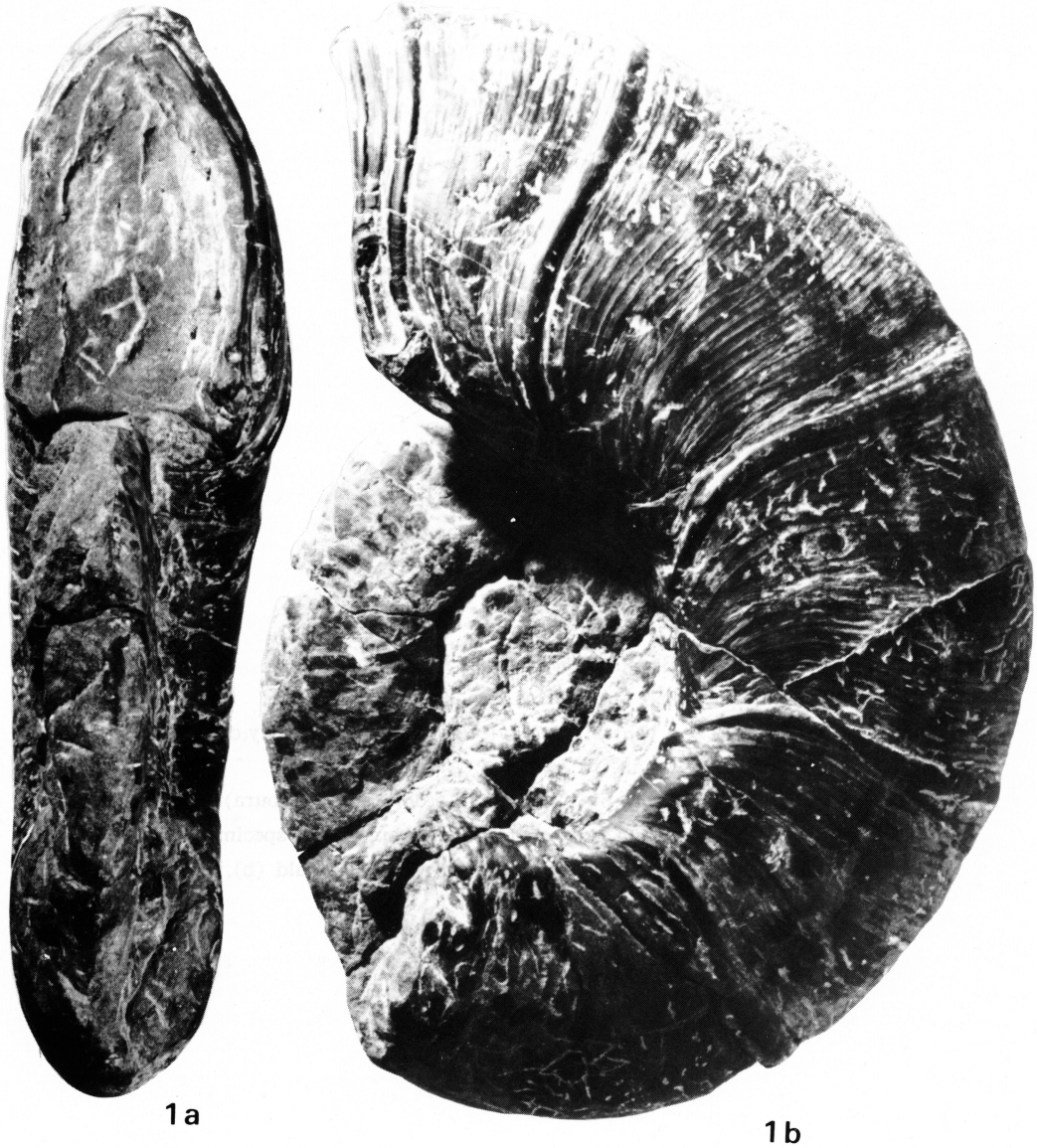
Explanation of Plate 12

Fig. 1. *Gaudryceras izumiense* sp. nov.
MT54 (M. TANI's Coll.), paratype, from Loc. 7 (Sobura).
Ventral (a), lateral (b) and frontal (c) views, ×2/3.


1c
1b
1a

Explanation of Plate 13

Fig. 1. *Gaudryceras izumiense* sp. nov.
MT82 (M. TANI's Coll.), paratype, from Loc. 7 (Sobura).
Frontal (a) and lateral (b) views of a somewhat compressed specimen, ×2/3.

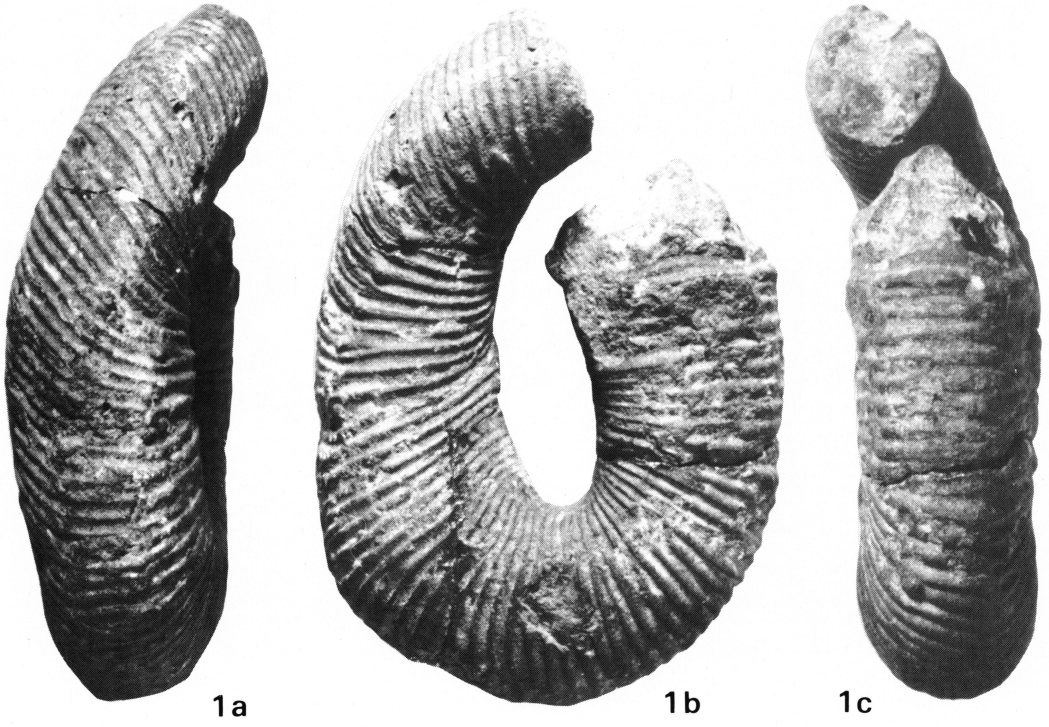


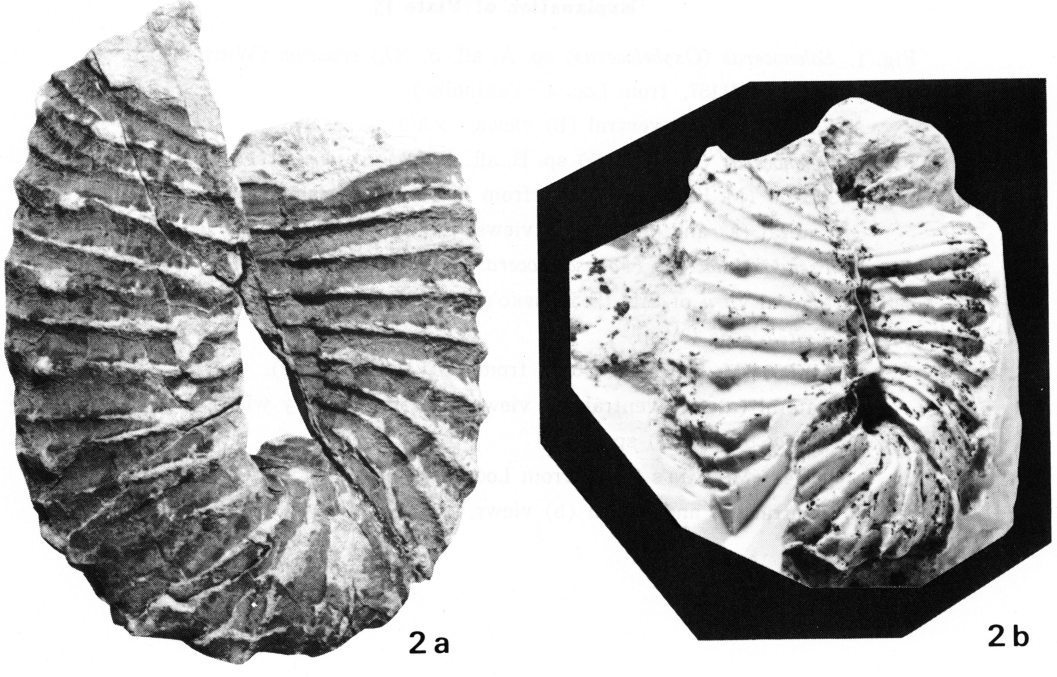
1a 1b

Explanation of Plate 14

Fig. 1. *Nostoceras* sp. B, aff. *N. hetonaiense* MATSUMOTO
MT137 (M. TANI's Coll.), from Loc. 4 (Takinoike).
Lateral (b) and ventral (a, c) views of a U-shaped body-chamber, ×1.

Fig. 2. *Nostoceras* sp. A, aff. *N. kernense* (ANDERSON)
OMNH. M1150 (coll. by K. KOGAKI), from Loc. 7 (Sobura).
Lateral views of the body-chamber of a compressed specimen (a), ×1, and of a rubber cast taken from the external mould (b), ×2/3.


1a
1b
1c


2a
2b

Explanation of Plate 15

Fig. 1. *Solenoceras* (*Oxybeloceras*) sp. A, aff. *S.* (*O.*) *crassum* (WHITFIELD)
OMNH. M1157, from Loc. 4 (Takinoike).
Lateral (a) and ventral (b) views, ×3/2.

Fig. 2. *Solenoceras* (*Solenoceras*) sp. B, aff. *S.* (*S.*) *reesidei* STEPHENSON
MK871 (M. KUWANO's Coll.), from Loc. 2 (Azenotani).
Lateral (a) and ventral (b) views, ×2.

Fig. 3. *Pseudoxybeloceras* (*Parasolenoceras*) sp.
Lateral view of SK4 (S. KANEKO's Coll.), from Loc. 4 (Takinoike), ×1.

Fig. 4. *Exiteloceras* (?) sp.
MK868 (M. KUWANO's Coll.), from Loc. 4 (Takinoike).
Lateral (a) and ventral (b) views of a fragmentary whorl, ×1.

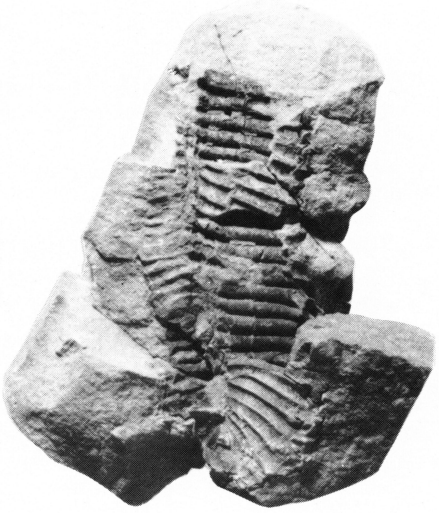
Fig. 5. *Hoploscaphites* (?) sp.
MT42 (M. TANI's Coll.), from Loc. 7 (Sobura).
Ventral (a) and lateral (b) views, ×1.

1a

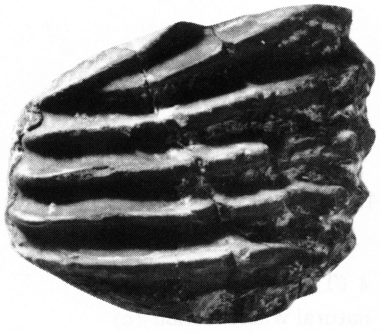
1b

2a

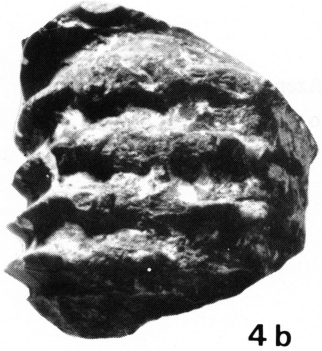
2b



3



4a



4b

5a

5b

Explanation of Plate 16

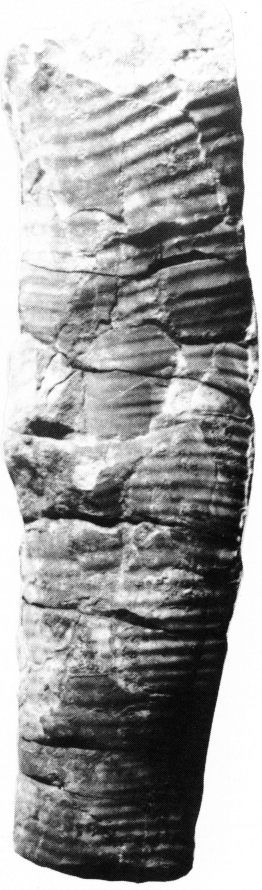
Figs. 1-2. *Neocrioceras* (*Schlueterella*) (?) sp.

1. SK3 (S. KANEKO's Coll.), from Loc. 4 (Takinoike).
   Lateral (a), ventral (b) views and natural whorl-section (c) of a fragmentary whorl, ×1.
2. Ventral view of OMNH. M2125 (coll. by T. NISHIOKA), from Loc. 4 (Takinoike), ×2/3.

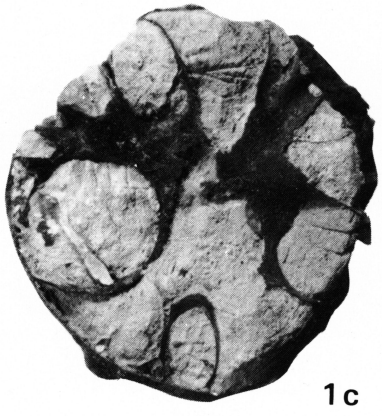
Fig. 3. *Diplomoceras* sp. cf. *D. notabile* WITEAVES
SK7 (S. KANEKO's Coll.), from Loc. 2 (Azenotani).
Lateral view of a specimen divided into three pieces, ×1/2.

1a

2



1b



1c

3